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VOLUME ? OF 2



FINAL REPORT HAMILTON STANDARD Q-FAN^R DEMONSTRATOR DYNAMIC PITCH CHANGE TEST PROGRAM

by

W. J. Demers, D. J. Nelson and H. S. Wainauski

HAMILTON STANDARD
DIVISION OF UNITED TECHNOLOGIES CORPORATION

Prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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16. Abstract								
structural characteristics response times, and fan/core engine compatibility during transient changes in blade angle, fan rpm, and engine power is reported in Volume 1. Volume 2 of 2, here included presents the Operating Procedures utilized and the Test Data obtained during this test program.								
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HSER 6700

TABLE OF CONTENTS Volume 2

<u>Section</u>	<u>Description</u>	<u>Page</u>
7.0	APPENDIX E	
	Operating Procedure 222PT-28A	193
	APPENDIX F	234
	Tabulation of Manometer	
	Photographs	235
	Forward Thrust Transients Reverse Through Feather	245
	Transients Reverse Through Flat Pitch	283
	Transients	519
	Reverse Thrust Transients	581
	Engine Logs	590

HSER 6700

APPENDIX E

OPERATING PROCEDURE

222PT - 28A

INSTALLATION AND OPERATION MANUAL

Q- FAN DEMONSTRATOR

Aug, 1974

REVISED OCT 9, 1974

PREPARED FOR NASA LEWIS RESEARCH CENTER

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HSER 6700

TABLE OF CONTENTS

												P	age No	2.
1.0	HARDWARE DESCRIPTION	•							•				1	
2.0	INSTALLATION		•		•			•			•		2	
3.0	FAN OPERATION			•		•	•			•			5	
4.0	COMPUTER OPERATION					•	•						18	
	INSPECTION OF HARDWARE													
6.0	LOG SHEETS AND CHECK LISTS	•	•	•	•		•	•			•		30	•
7.0	CONFIGURATION CHANGES												36	

1.0 Hardware Description

The Q-Fan Demonstrator is a high bypass ratio, low pressure ratio, geared, variable pitch fan engine which utilizes a Lycoming T-55-L-11A gas turbine as the core engine. The Q-Fan has the following design characteristics.

Bypass Ratio	17:1
Fan Pressure Ratio	1.15:1
Static Thrust Rating	7000 pounds
Weight Flow	440 lb/sec
Fan Diameter	55 inches .
Number of Fan Blades	13
Number of ExitGuide Vanes	7
Hub/Tip Ratio	.46
Gear Ratio	4.75:1
Fan Tip Speed	810 ft./sec.
Core Engine Power	3750 HP

The fan rotor blades are aluminum spar/fiberglass shell type and are mounted in a steel disc. The fan duct includes a support structure to which the exit guide vanes are attached. The vanes in turn support the fan/engine mounting ring. The duct is also the mounting point for attachment to the test stand, and for the inlet and exit nozzles. Pitch change is accomplished by a hydraulic actuator connected to trunnions on the blades through a scotch yoke arrangement. The actuator fluid is supplied from an external pump and is metered by a Moog valve. The valve is controlled either by a thrust setting potentiometer through a computer which coordinates blade angle and the engine fuel control, or by a beta potentiometer which controls only blade pitch change through an analog controller.

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1.0 (Continued)

The beta potentiometer is used in conjunction with a power lever potentiometer which controls the engine fuel control.

Lubrication of the fan is provided by means of an external pressure pump and tank. Scavenging is also by means of an external pump.

Provisions are made for the instrumentation to monitor the necessary engine and performance characteristics.

A copy of drawing number SK83400, Propulsion System, Variable Pitch Fan, Aircraft is included in the appendix for reference.

- 2.0 <u>Installation</u>
- 2.1 General
- 2.1.1 This procedure covers only the installation of a completely assembled fan onto a test stand.
- 2.2 Q-Fan Installation
- 2.2.1 Attach the fan to the test stand at the mounting plate with 24 bolts supplied by the test facility. All lifting of the fan must be accomplished only on the mounting ring.
- 2.3 Hydraulic Provisions
- 2.3.1 The fan will be supplied with all the hydraulic lines terminating at the end of the pylon. The lines will be "tagged" and the numbers on the tag will be a reference to callouts on drawing number SK89010. Connections to these lines are defined on the drawing.
- 2.3.2 The fluid for both pitch change and lubrication is MIL-L-23699.
- 2.3.3 A Denison pump rated 35 gpm at 5000 psi is supplied to provide fan pitch change actuation fluid. This unit requires 440 volt, 3 phase power at a maximum of 100 amps.



- 2.3.4 A Yahn pump rated 15 gpm at 50 psi is supplied to provide fan lubrication fluid. This unit requires 440 volt, 3 phase power at a maximum of 60 amps.
- 2.3.5 A Viking pump rated 35 gpm at 2000 psi is supplied to scavenge the fan.

 This unit requires 440 volt, 3 phase power at 30 amps max. It also requires control power of 115 volts at 15 amps.
- 2.3.6 A Brown & Sharp pump rated 26 gpm at 100 psi is supplied to transfer oil from the lubrication to the pitch change system. This unit requires 440 volt, 3 phase power at a maximum of 30 amps.
- 2.3.7 Cooling water to a flow of 35 gpm is required to cool the two pressure pumps.
- 2.3.8 After all connections are made, all pressure lines must be bled to remove all air. This may be accomplished by exercising the power and blade angle levers with the fan not running.
- 2.3.9 Frior to operation, the installation must be checked out per the following sequence.
- 2.3.9.1 Static Checks (engine not running)
- 2.3.9.1.1 Digital Controller
- 2.3.9.1.1.1 Check PLA at engine and readout for controller settings of idle, 70, 90, and 100%. During this check, also check hydraulic system for pressure and leakage.
- 2.3.9.1.1.2 Check blade angle at blades and readouts for controller settings of 39, 80, 120, and 158°. During this check, also check hydraulic system for pressure and leakage.
 - 2.3.9.1.2 Computer
- 2.3.9.1.2.1 Set parameters TSLRU and TSLLU at 98%. Set parameters TSLLL and TSLRL at 2%. Recall tables 3 and 4. Using the thrust setting potentiometer, set values of TCL which give specific values of PLA and Blade angle in tables 3 and 4. Check settings at readouts and at blades and at engine PLA.

- 2.3.9.2.0 Lube System
- 2.3.9.2.1 With engine not running, check lube system for the fan for correct pressure and flow. Also check for leaks in system. (40-50 psig & 12-16 qpm).
- 2.3.9.3.0 Dynamic Checks
- 2.3.9.3.1 Digital Controller (manual operation)
- 2.3.9.3.1.1 Start fan
- 2.3.9.3.1.2 Check operation at GI power (12° PLA) and B of 39°, 80°, 120° and 158°.
- 2.3.9.3.1.3 Check operation at B of 56° and PLA's of 40°, 80° and 100°.
 - 2.3.9.3.2 Coordinated Operation (computer)
- 2.3.9.3.2.1 Recall table 3 and change all PLA values to idle (12°).
- 2.3.9.3.2.2 Set TSLLL, TSLLU, TSLRL, and TSLRU per 1.2.1.
- 2.3.9.3.2.3 With fan at GI, switch from "MAN" to "AUTO".
- 2.3.9.3.2.4 Using the thrust setting potentiometer varify that B changes per Table 4.
- 2.3.9.3.2.5 At idle, reset Table 3 to values of 12° and 50° PLA.
- 2.3.9.3.2.6 Using the thrust setting lever, verify that PLA changes per Table 3.
- 2.3.9:3.2.7 Return values of TSLLU, TSLRL, and TSLRU to original values.
 - 2.3.9.4.0 Protection Devices
 - 2.3.9.4.1 Overspeed
- 2.3.9.4.1.1 Set O'speed selector on failsafe panel to "none".
- 2.3.9.4.1.2 Set 0'speed potentiometer for 12960 rpm (80% of N2).
- 2.3.9.4.1.3 With fan in "MAN" increase speed until O'speed device trips.
- 2.3.9.4.1.4 Check speed at which trip occurs vs. setting and determine that fan power goes to idle, and blade angle does not change.
- 2.3.9.4.1.5 Reset O'speed potentiometer for 16,200 rpm (N2).
 - 2.3.9.4.2 Overtorque

- 2.3.9.4.2.1 Set O'torque selector on failsafe panel to "none".
- 2.3.9.4.2.2 Set O'torque potentiometer for 1040 ft. 1bs (80%).
- 2.3.9.4.2.3 With fan in "MAN" increase torque until O'torque device trips.

- 2.3.9.4.2.4 Check torque at which trip occurs vs. setting and determine that fan power goes to idle, and blade angle does not change.
- 2.3.9.4.2.5 Reset O'torque potentiometer for 1350 ft. 1bs.
 - 2.4 Electrical Provisions
 - 2.4.1 A motor/generator set will be provided to supply the 28 volt DC power for the engine starter. This unit requires 440 volt, 3 phase power at a maximum of 45 amps. Connections to the starter are shown on drawing number SK89019.
 - 2.4.2 The digital controller requires 115 volt power at a maximum of 20 amps.
 - 2.4.3 The computer and teletype require 115 +2 volt power at a maximum of 30 amps.
 - 2.4.4 The structural instrumentation power requirements are shown on drawings 11X5552.
 - 2.5 <u>Instrumentation Provisions</u>
 - 2.5.1 The instrumentation to operate and monitor the fan is listed in HS Document 222PT-26. The fan interfaces will be "tagged" and the numbers on the tag will be a reference to callouts on drawing number SK89019. Connections to these interfaces are defined on the drawing.

 Drawings SK84366-1, SK84366-2, 222X-16A, 222X-16B, 222X-16C, 222X-16D and 11X5552 are included as references. These drawings show the manner in which the instrumentation was hooked up at the Hamilton Standard test site.
 - 2.6 <u>Control Provisions.</u>
 - 2.6.1 The connection of the computer to the teletype and the analog controller, and of the analog controller to the fan is shown on drawing SK89019.
 - 3.0 Fan Overations
 - 3.1 General

This section defines the operating procedures for the Q-Fan Demonstrator. These procedures take precedence over test plans as far as fan operation

3.1 (Continued)

is concerned. The Hamilton Standard test engineer will resolve any operating conflicts.

3.2 Operating Limits

The following are the maximum operating limits which should not be exceeded at any time during operation of this powerplant.

Engine temperature - Tt7 mgt - per figure 1 Engine torque - 1300 ft. lbs. max. - 30 min.
1150 ft. lbs. max. - continuous Fan structural limits - in accordance with Figure 2 Engine speed N1 - 18,720 rpm max. N2 - 16,000 rpm max. Fan speed - 3365 rpm max. Oil temperature Engine - 280°F (1.36°C) max. Gearbox - 250°F oil out max. 200° oil in max. Oil pressure Engine - 50 psig min. (above normal rated power) 35 psig min. at 70-80% Nl Gearbox - 40 psig min. Fan bearings - 275°F Vibrations Fan Gearbox In accordance with Figure 3

Engine Surface Temperature

Fan Duct

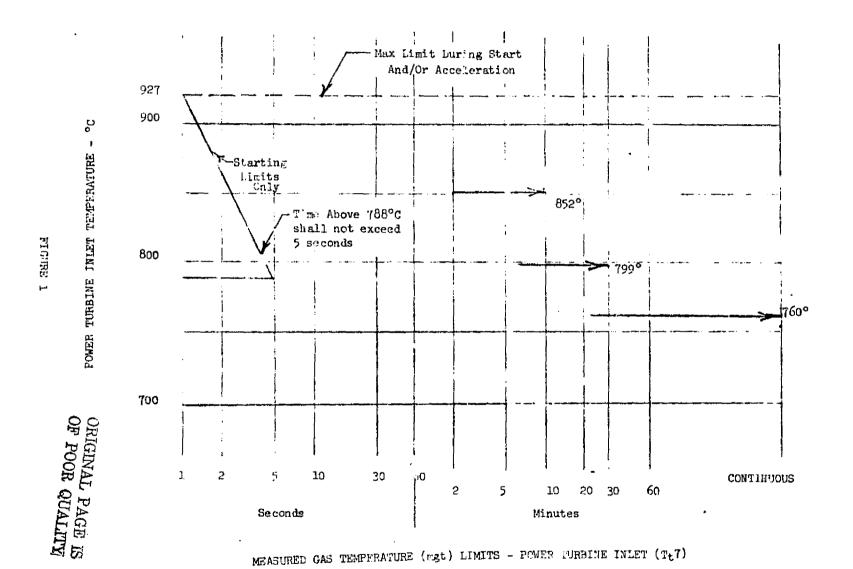
Location	Max. oF Above Ambient
Enant Bueno Loft	210°
Front Frame Left	280°
Compressor Front Left	
Ambient (2)	200°
Compressor Rear Left	750°
Combuster Left	530°
Front Frame Right	210°
Combuster Right	280°
Compressor Rear Right	420°
Compressor Front Right	530°

Engine Compressor Inlet - 160°F Gearbox Oil Flow - 12-16 qpm

3.3 <u>Instrumentation</u>

The instrumentation for the fan is defined by HS Document 222PT-26 Instrumentation Plan.

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HSER 6700

Q-FAN DEMONSTRATOR

STRESS LIMITS AND CORE-TO-SHELL RATIOS

			LIMITS	CORE-TO-SHELL
Blades	15 1/4" FT	(Edgewise)	*5 000 psi ·	N.A. (Gage on core)
	14 1/4" FT	(Flatwise)	± 5000 psi	,0.96
	5" FT	(Tip Bending)	±9000 psi	0.75
	3 1/2" FT	(Chordwise at Core TE)	±2000 psi*	N.A. (Use F/G Str)
	3 1/2" FT	(VEE)	±3000 psi	0.70

*For F/G Stress, use E=3 x 10⁶ psi.

Core T.E. If the TE gage shows response near
1200 cps, reduce the stress limit to ±500 psi.

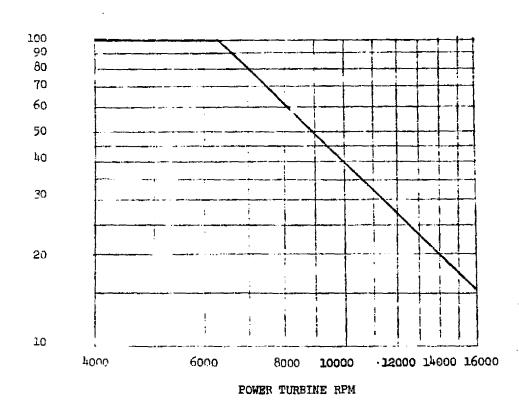
 Vanes:
 All gages
 ±5000 psi
 N.A.

 Barrel:
 All gages
 ±15,000 psi
 N.A.

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VIBRATIO: LIMITS

FOR SHROUD AND GEARBOX



Limit based on 2.5 G acceleration at 1P frequency, truncated to 100 Mils L.A. below 6400 RPM.

MILS D.A.

VIBRATIORY DISPLACEMENT

3.4 Pre-Start Inspection

Immediately prior to motoring or starting the fan, the following items must be checked. A check list (Ref. section 6.2) must be filled out and signed by the responsible Engineer for this inspection.

- Inlet and exhaust covers have been removed.
- Fin duct is free of foreign objects.
- Fan blades and final turbine stage have not suffered FOD.
- Oil supplies for both the lubrication and pitch change system are at proper levels.
- Inspect the fan for any evidence of leakage.
- All fairing and cowling fasteners are properly secured.
- All accessible instrumentation wiring and hardware is secure.
- The ground area, within an area 80 feet in diameter centered under the fan, must be free of any loose material which could be "vacuumed" into the fan.

3.5 Pre- Start Procedure

- 3.5.1 Analog Controller (reference photograph in Appendix)
 - a. Engage circuit breaker (back of console).
 - b. Turn on power supply (power supply panel). (set to 24 7DC)
 - c. Press power switch (controller panel).
 - d. Press reset switch (shutdown light must be out) (idle/failsafe panel)

 - e. Press manual switch (light must be lit) (idle/failsafe panel).

 f. PLA static position potentiometer set at 500 Control Controller panel
 - g. PLA forward loop gain potentiometer set at 000 Controller panel
 - h. PLA feedback gain potentiometer set at 831. Controller panel Controller panel
 - i. Beta potentiometer set at 500. j. Beta forward loop gain potentiometer set at 350.
 - k. Beta feedback gain potentiometer set at 513.
 - 1. N2 overspeed potentiometer set at 8.6.
 - m. Overtorque potentiometer 'st at 9.3

 - n. PLA idle potentiometer set at 1.7.o. B idle potentiometer set at 1.1 (for Rev thru
 - Fea transients only) B idle potentiometer set at . (for Rev thru Flat
 - Flat Pitch transients only)
 - p. N2 speed switch set at "None".
 - Torque switch set at "None".
- Teletype (if needed for test) (the teletype should be shut off when not 3.5.2 needed for test)
 - a. Turn on teletype to "LINE" (front of teletype)

Controller panel

Controller panel Idle/Failsafe

Idle/Failsafe

Idle/Failsafe Idle/Failsafe Idle/Failsafe

Idle/Failsafe

b. He sure tape punch is 'OFF" (Left side of teletype)

3.5.3 Computer

The computer must be kept at an ambient temperature between 68 and 75°F.

3.5.4 Other Controls

Postion potentiometers, levers, and switches as follows:

a. Power lever potentiometer

"0%"

b. Leta lever potentiometer

"39°"

- c. Starter switch "Off" (momentary switch)
- e. Starting fuel switch "Off".
- f. Electrical power "On".
- g. Fuel shutoff valve "Open".
- h. Fuel boost pump "On".
- i. Gearbox oil pump "On"
- j. Shavenge pump "On"
- k. Fransfer pump "On"
- 1. Pitch change pump "On"
- m. Heat exchanger cooling water or heating elements as necessary "On"
- n. Starter generator "On"

3.5.5 Check the following:

- a. All of the alarm lights except the overspeed light are off.
- b. Gearbox oil pressure is approximately 45-50 psig and flow is 12-16 qpm
- c. Fuel pressure is approximately 15 psig
- d. Pitch change oil pressure is approximately 2000 psig.

3.6 Starting Sequence

- 3.6.1 Actuate the following simultaneously:
 - a. Ignition switch "On"
 - b. Starter switch "On"
 - c. Reset switch on idle/failsafe panel if overspeed light is on
 - d. Starting fuel switch "On" (at 10% N1, if needed)
 - e. Jower lever potentiometer to idle (10%) (at 10-12% N1)
 - f. Release reset switch at 10% N1

<u>CAUTION</u>: Measured gas temperature (mgt) must be closely monitored during the start. If the limits indicated in Figure 1 are exceeded, abort the start.

3.6.2 Aborted Start

If the start must be aborted, perform the following:

- a. Starting fuel switch "Off"
- b. Fower lever potentiometer "O"
- c. Ignition switch "Off"
- d. Starter switch "Off"



Overtemperature - An overtemperature exists if the mqt (Tt7) limit of 927°C (1700°F) is exceeded at any time. If exceeded, a hot end inspection must be performed.

A significant change in mgt at any power level is cause for investigation, whether or not the indicated limit in figure 1 is exceeded.

3.6.3 Ignition

De-energize starting fuel solencid at 420 to 430°C (790 to 810°F) mgt, or at 25 percent N1, whichever occurs first. De-energize starter and ignition at 38 to 51 percent N1. Engine will continue to accelerate to ground idle.

CAUTION: If there is no indication of oil pressure by the time the engine has reached G.I., immediately shut down engine and investigate for cause.

NOTE: If acceleration is intermittent, if N1 remains constant for more than 3 seconds, or if N1 decreases after starter is de-energized, switch ignition and igniter fuel solenoid to ON until engine accelerates to ground idle.

3.6.4 Starting Time

Successful starts should be accomplished in less than 30 seconds on a standard day. If start is aborted, wait 15 seconds after N1 has returned to zero before attempting restart. This permits excess fuel to drain from combustion chamber.

3.6.5 Post Start Check

With engine speed stabilized at ground idle, check the following:

a. Compressor rotor speed (N1) - 49.7 to 55.0 percent

3.6.5 Continued

- b. Minimum engine oil pressure 20 psig
- c. Measured gas temperature 510°C (950°F) max.
- d. Maximum oil temperature 88°c (190°F)

3.7 Oil Pr:ssure

The engine oil pressure should increase to 50 to 90 psig at normal rated power or higher and the maximum needle oscillation shall not exceed 10 psig.

3.8 Operating Limits

Operation will at all times be in accordance with the operating limits in section 2.2.

3.9 Engine Shutdown

3.9.1 Temperature Stabilization

Upon c mpletion of the engine run, operate the engine at flight idle speed until the mgt stabilizes (usually a maximum of 2 minutes). Stabilizing temperature will reduce the possibility of internal warpage due to abrupt temperature variations that accompany a sudden shutdown from high power.

3.9.2 Shutdown

Move power lever (N1) to ground idle; then shut down engine by setting levers and switches as outlined below:

Power lever (N1) OFF

Fuel booster pump OFF

Fuel shutoff valve OFF

Engine electrical power OFF

3.9.3 Coastdown

Following shutdown, note time of compressor rotor coastdown to zero rpm.

This should not be less than 25 seconds. If less than 25 seconds, investigate engine for cause. Coastdown should occur with no rubbing or abnormal noises.

Observe mgt. If mgt rises above 350°C (662°F), motor engine with ignition,

3.9.3 Continued

starting fuel, and power lever in OFF positions until mgt falls to approximately 260°C (500°F).

3.9.4 Chip Detector

A chip detector indication shall be reported to the HS Engineer who will determine what action should be taken.

3.10 Emergency Shutdown

If an emergency shutdown is necessary, proceed as follows:

Power Lever (N1)

OFF

Fuel shutoff valve

OFF

Electrical power

OFF

Emergency shutdowns should only be made if, in the opinion of either the operator or the engineer, continued running may result in damage to hardware or danger to personnel.

- 3.11 After Operation Inspection
 - Immediately after operating the fan, the following inspection must be performed.
- 3.11.1 Install inlet and exhaust covers if shutdown is to be for two or more hours and access to the fan is not required.
- 3.11.2 Visually examine fan and engine for any changes which may have occurred during run.
- 3.11.5 Check that all data taken during run is properly identified and collected.
- 3.11.4 Check log sheets to insure that they are complete and correct.
- 3.11.5 Write up any problems that need correction in the test log book.
 - 3.12 Manual (Uncoordinated) Operation

To operate the fan by the analog controller requires the use of the power lever potentiometer or the beta potentiometer. Both of these potentiometers are located on the controller panel of the analog controller. Running in this rade is limited to expectably steady state running (i.e.,

3.12 Continued

PLA). Blade angle is controlled by rotating the beta potentiometer clockwise to increase blade angle and counterclockwise to decrease
blade angle. Power is controlled by rotating the power lever potentiometer clockwise to increase power and counterclockwise to decrease power.
Caution should be exercised during any blade angle or power lever excursions to insure that the fan is not subjected to an overspeed, overstress,
overtorque, or overtemperature condition.

3.13 Coordinated Operation

Transient operation of the fan through the computer is accomplished by programming the various desired operating parameters into the computer and varying thrust with the thrust setting potentiometer. The parameters which may be varied are:

- a. TSLLL- For forward thrust transients, the lowest thrust that can be set with the thrust setting potentiometer (should be set at flight idle 45°). For reverse thrust transients, the thrust setting at which the step transient (to reverse) in the computer occurs (should be set at .1° below the high thrust setting of the transient.
- b. TSILU For forward thrust transients, the low thrust setting at which the desired transient starts (should be set .1° above the low thrust setting of the transient). For reverse thrust transients, the highest thrust that can be set with the thrust setting potentiometer.
- c. TSLRU The high thrust setting for either forward or reverse transients.
- d. TSLRL For forward thrust transients, the lowest thrust that can be set with the thrust setting potentiometer (set same as TSLLL). For reverse thrust transients, the low thrust setting of the transient.
- e. TDOT1 The thrust setting potentiometer rate for increasing blade angle if a slope is desired.

3.13 Continued

- f. TDCT2 The thrust setting potentiometer rate for decreasing blade angle if a slope is desired.
- g. Co The thrust setting potentiometer rate for increasing or decreasing blade angle. (for step, Co=0, for a slope, Co=1)
- h. Table 3 The steady state power lever schedule versus the thrust setting lever position
- i. Table 4 The steady state blade angle schedule versus the thrust setting lever position.
- J. Table 5 The rate limit of the changing blade angle versus blade angle for increasing blade angle [(db/dt) as a function of B]
- k. Table 6 The rate limit of the changing blade angle versus blade angle for decreasing blade angle
- Table 1 The maximum allowable power lever angle as a function of blade angle when going to reverse thrust.
- m. Table 2 The maximum allowable power lever angle as a function of blade angle when leaving reverse thrust
- n. DBREVC The amount of blade angle overshoot from the desired blade angle for steady state reverse thrust
- o. BETACX The blade angle at which the time constant of the blade angle overshoot of item n is initiated.
- p. RTIMEC The time constant of item c which returns the blade angle from the overshoot to the desired steady state reverse thrust.
- q. PLARMX The power lever angle during the blade angle overshoot of item n.

The working program, which has been provided, contains a set of values for the variables. The plan of test for the specific test will contain other values for each variable. The procedure for operating the fan through the computer is given in b.c.

4.0 Computer Operation

- 4.1 Loading Procedure (Reference Figure 4-10)
 - A. Engage circuit breaker (back of console).
 - B. Turn on computer power (key on control console).
 - C. Set three toggle switches on power panel to up position. Press one of the push buttons and hold until power is up.
 - D. All levers on the control console up

 Levers "INT" and "EXE" are momentary levers and will return automatically to the up position. All other levers must be manually returned to the up position.
 - E. The following procedure prepares the computer to accept the tape programs:
 - Depress lever "INT" and release (momentary lever)
 - Depress levers "10" and "14"
 - Set rotary switch to "ADR/MRD"
 - Depress lever "EXE"
 - Return all levers to up position
 - Depress levers "9", "11", "12" and "SGL"
 - Set rotary switch to "OFF/MWR"
 - Depress lever "EXE"
 - Return all levers to up position
 - Depress levers "10", "11", and "13"
 - Set rotary switch to "ADR/MRD"
 - Depress lever "EXE"
 - Return all levers to up position
 - Depress levers "0" and "SGL"
 - Set rctary switch to "OFF/MWR"
 - Depress lever "EXE"
 - Return all levers to up position

HSER 6700

4.0 Continued

- Depress levers "10", "11", "13" and "14"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "9", "11" and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "10", "11", "12" and "13"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "0" and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "10", "11", "12", "13" and "14"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position.
- Depress levers "9", "11" and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "9" and "11"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position

HSER 6700

4.0 Continued

- Depress levers "0", "1", "3", "5", "7", and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "9", "11", and "14"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "8", "9", "12", "13", "14", "15" and "GGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "9", "11", and "13"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "1", "6", "7", and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "9", "11", "13" and "14"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "8" and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position

4.0 Continued

- Depress levers "9", "10", "11" and "12"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "3", "6", "7", "8", "11", "12", "15" and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "9", "10", "11", "12" and "14"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "3", "6", "7", "8", "11", "12", "14" and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "9", "10", "11", "12" and "13"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "3", "6", "7", "8", "11", "12", "15" and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position
- Depress levers "7", "10", "11", "12", "13" and "14"
- Set rotary switch to "ADR/MRD"
- Depress lever "EXE"
- Return all levers to up position

4.0 Continued

- Depress levers "6", "8", "11", "12", and "SGL"
- Set rotary switch to "OFF/MWR"
- Depress lever "EXE"
- Return all levers to up position

The computer is now ready to accept programs from tape.

4.2 Tape Loading - Reader

To load a tape into the high speed reader, perform the following steps.

- Set the three position toggle switch on the reader to "LOAD"
- Raise the tension bar on the reader
- Tapes are loaded to run from right to left
- For "fan fold type" tapes, pick up the tape with "TOP" up and the arrow pointing to the left
- For "rolled type" tapes, pick up the tape in the right hand with the tape unwinding from the top of the roll.
- Load tape in the wells of the reader and through the reader. There must be blank tape (single row of perforations) to the right of the reading mechanisms.
- Lower the tension bar on the reader.
- Set the three position toggle switch to "RUN"

The high speed reader is now ready to enter programs into the computer. Specific instructions to load each applicable program are given in 4.4.2, 4.4.3, 4.4.4 and 4.4.5.

4.3 Tene Removal

- 4.3.1 To remove the tape from the high speed reader, perform the following steps:
 - Set the three position toggle switch to "LOAD"
 - Raise the tension bar on the reader.
 - Remove the tape.



- 4.3.1 Continued
 - Return all levers on the computer control console to the up position.
 - If the reader is not going to be used again, set three position toggle switch to "OFF"
 - 4.4 Tape Loading Computer
- 4.4.1 Types must be loaded into the computer in the following sequence:
 - a. general loader tape
 - b. data comparer and debugger
 - c. working program
 - d. data tape (if used)
- 4.4.2 To load the general loader:
 - load the tape into the reader per previous instructions
 - depress levers "9" and "11" (50)
 - set rotary switch t "ADR/MRD"
 - depress lever "EXE"
 - depress lever "INT"
 - set rotary switch to "PSW"
 - depress lever "RUN"
 - depress lever "EXE"

After tape runs

- raise all levers to up position
- remove tape per previous instructions
- 4.4.3 To load the data comparer and debugger
 - load the tape into the reader per previous instructions
 - decress levers "l", "3", "h" and "6" (5A00)
 - set rotary switchto "ADR/MRD"
 - depress lever "EXE"
 - depress lever "INT"
 - set rotary switch to "PSW"

4.4.3 Continued

- depress lever "RUN"
- depress lever "EXE"
- the teletype will print "BIAS=pp8d" then "NORMAL END" after tape runs
- raise all levers to up position
- remove tape per previous instructions

4.4.4 To load the working program

- . load the tape into the reader per previous instructions
 - depress levers "9" and "11" (50)
 - set rotary switch to "ADR/MRD"
 - depress lever "EXE"
 - depress lever "INT"
 - set rotary switch to "PSW"
 - depress lever "RUN"
 - depress lever "EXE"
 - after tape runs
 - raise all levers to up position
 - remove tape per previous instructions

4.4.5 To load a data tape on top of the working program:

- load the tape in the reader per previous instructions
- depress levers "1", "3", "4" and "6" (5A00)
- set rotary switch to "ADR/MRD"
- depress lever "EXE"
- depress lever "INT"
- set rotary switch to "PSW"
- depress lever "RUN"
- depress lever "EXE"
- teletype will print "BIAS \$\dd8d" then "NORMAL END" after tape runs

- 4.4.5 Continued
 - raise all levers to up position
 - remove tape per previous instructions
 - 4.5 New Data Tape
- 4.5.1 To punch a new data tape
 - select option HO (see 4.8.3)
 - recall parameter 25 (this is data version)
 - update parameter by, 1 (ie: from 1 to 1.1)
 - leave option HO
 - raise lever "RUN"
 - set rotary switch to "ADR/MRD"
 - depress levers "1", "4", "5", and "6" (4E00)
 - depress lever "EXE"
 - depress lever "INT"
 - set rotary switch to "PSW"
 - depress lever "RUN"
 - depress lever "EXE"
 - teletype will print "CLUB"
 - depress REMOTE button on high speed punch
 - load tape in punch
 - punch runs from right to left
 - raise bar on punch and insert tape
 - lower bar
 - be sure there are 3 to 4 folds of leader on tape, to get more leader, depress punch power and depress lever, turn off punch power
 - type "l", "\$", "\$", "\$", "L" and "RETURN"
 - type "l", "D", "\$", "8", "H" and "RETURN"
 - type letter "0" and "RETURN"
 - depress lever "EXE"

4.5.1 Continued

- be sure to get 3 or 4 folds of trailer on tage
- depress lever "INT"
- depress REMOTE button
- raise all levers to up position
- remove tape from punch and mark with data version number

4.6 Data Tape Verification

4.6.1 To verify data tape

- load tape in reader
- depress levers "1", "4" and "6" (4A00)
- set rotary switch to "ADR/MRD"
- depress lever "EXE"
- depress lever "INT"
- set rotary switch to "PSW"
- depress lever "RUN"
- depress lever "EXE"
- if the tape is correct it will be read completely, if there is an error it will stop
- remove tape from reader
- raise all levers to up position.
- if there is an error in the tape, punch a new tape

4.7 Teletype to Computer Connection

- 4.7.1 To hook the teletype to the computer perform the following steps:
 - Depress lever "7" on the computer control console
 - Set rotary switch to "ADR/MRD"
 - Depress lever "EXE"
 - Depress lever "INT"
 - Set rotary switch to "PSW"
 - Depress lever "RUN"

4.7.1 Continued

- Depress lever "EXE"
- Type "ESC" on teletype
- Teletype will print a sign on message
- Raise lever "7" to up position
- Turn key on computer console to "L(CK"

The teletype is now connected to the computer and is ready for use.

4.8 Computer Options

- 4.8.1 There are five options which can now be taken.
 - LI This is a list of all the parameters in the computer program and includes values which should not be changed. The printout will show the parameter number, parameter designation, and parameter value.
 - DI In this option a particular parameter may be recalled, but not changed.
 - HO In this option a particular parameter may be recalled and charged.
 - SE In this option, the computer outputs are connected to the fan, and the fan will respond as a function of thrust setting potentiometer position.
 - RU In this option, the computer outputs are connected to the fan, and the fan will respond to the transient programmed into the computer.

4.8.2 To call option LI

- Type "ESC" on teletype

- The teletype will print "#"
 Type "I" "N"
- The teletype will print a complete list of the single parameters
- Type "T" "A"
- The teletype will print a complete list of the parameters of 12 tables
- To obtain a list of a particular table:

for tables 1 thru 9 - type the table number and RETURN" for tables 10 thru 12 - type the table number

To leave LI

- type "RETURN"



- 4.8.3 To call option DI
 - Type "ESC" on teletype
 - Teletype will print -
 - Type "D", "I"
 - Teletype will print -
 - To get any parameter, type the parameter number and "RETURN"
 - The teletype will print the value of the parameter

To leave DI .

- Type "RETURN"
- Teletype will print "SYSTEM RUNNING"
- 4.8.4 To call option HO:
 - Type "ESC" on teletype
 - Teletype will print -
 - Type "H" , "O"
 - Teletype will print +
 - To obtain the parameter to be changed, type the parameter number and "RETURN"
 - The teletype will print the value of the parameter
 - Type the new value of the parameter and "RETURN"
 - The teletype will print the new value
 - Type "RETURN"
 - Continue to change parameters as desired

To leave HO

- Type "RETURN"
- The teletype will print "SYSTEM RUNHING WITHOUT OUTPUTS" and will print the blade angle and the power lever angle that the fan was set at when the option was called.
- 4.8.5 To verify computer operation or changes to the program.

The effect of the changes can be observed on the meters on the computer

4.8.5 Continued

console. Set the meter selection switches as follows:

- Meter 1 set at TSLR. (position 5)
- Meter 2 set at blade angle linearized (position 1)
- Meter 3 set at power lever angle corrected (position 3)
- v performing the transient with the thrust setting potentiometer, the blade
- . the and wer lever angle response will be shown on the respective meters and can be compared to the programmed transient (only the step transient can be simulated).
- 4.8.6 To call option SE
 - when calling this option, the fan and the thrust setting potentiometer must be at idle
 - type "ESC" on teletype
 - teletype will print
 - type "S" "E"
 - teletype will print "SYSTEM RUNNING WITH OUTPUTS"

The desired transient may now be performed using the thrust setting potentiometer. Set the potentiometer for the beginning setting for the transient

To leave SE

- type "RETURN"
- 4.8.7 To call option RU
 - Type ESC on teletype
 - Teletype will print
 - Type "R", "U"
 - Teletype will pring "SYSTEM RUNNING WITH OUTPUTS"

4.8.7 Continued

The desired transient may now be performed using the thrust setting potentiometer.

To leave RU

- Type "RETURN"

4.9 Fan Operation

With the computer in option "SE", the fan operating st a ground idle condition in the "MANUAL" mode and the thrust setting potentiometer set at flight idle (45-50°) press the "IDLE" button on the idle/failsafe panel of the digital controller and then the "AUTO" button on the idle/failsafe panel of the digital controller. The thrust setting potentiometer will now control the fan. Rotate the potentiometer to a point, 1° to 2° above the initial point of the transient, leave option SE and enter option RU, and then perform the transient. Rotating the potentiometer clockwise from idle will increase positive thrust, counter clockwise will decrease positive thrust, and then increase negative thrust.

4.9	Construed
	To leave the "AUTO" mode, press the "IDIE" button on the idle/fails af
	panel. A sample operating sequence is included in Appendix A.
5.0	Inspection of Hardware
5.1	Other than the daily inspections of the hardware noted in 3.4 no other
	inspections are required.
6.0	Log Sheets and Check Lists
6.1	Log Sheets
	A log sheet shall be prepared each time the rig is operated.
6.1.1	Entries shall be made in accordance with the following schedule.
6.1.1.1	For each start
6.1.1.2	For each test condition or at 15 minute intervals
6.1.1.3	Prior to each shutdown
6.1.1.4	Any unusual occurrence or failure
6.1.2	The log sheet shall include the following minimum information.
6.1.2.1	Date and time of entry
6.1.2.2	Name of test
6.1.2.3	Ambient pressure and temperature
6.1.2.4	Engine speeds, torque, and Tt?
6.1.2.5	Operating time and total operating time
6.1.2.6	Test number (to identify with recorded data and test plan)
6.1.2.7	Fan blade angle
6.1.2.8	Fan gearbox oil-in pressure and temperature and oil-out temperature
6.1.2.9	Fan gearbox oil flow
6.1.2.10	Operator's, helper's and engineer's name
6.1.2.11	Notation of questionable or unusual occurrences
6.1.2.12	Fan gearbox, engine and duct vibration levels
61212	Selected engine cumface and apoling of tampowature

- 6.2 Check Lists
- 6.2.1 The following check list must be prepared and used during the NASA test program. Samples of each check list are included.

Pre-operation inspection

After operation inspection

Static operation inspection

Daily log

Date:

Q-Fan Demonstrator

Pre-Operation Inspection

ITEM	OPER	ENGR
Remove Inlet and Exh Covers		
Inspect Fan Duct	-	
Inspect Fan Blades		
Rotate Fan by hand and Check for Rubbing		
Inspect Engine Final Turbine Stage		
Check Fuel Supply		
Check Engine Oil Level		
Check Fan Gearbox Oil Level		
Inspect Filler Caps for Security		
Inspect Engine for Leakage		
Inspect Cowling and Pylon Fasteners		
Inspect Accessible Instrumentation Wiring and Hardware		
Inspect Ground Area for Loose Objects		
Clear All Personnel from Engine Air Inlet and Exhaust Areas		
Denison Pump Cn	 -	
Make Start per prescribed Procedure:		
Energize Starter, starter fuel solenoid, and igniter plugs simultaneously.		
When N1 Reaches 10-12%, Move the Throttle to Ground Idle (10-13° Throttle Position).		
De-energize the Starter at 39% Gas Producer Speed.		
De-energize the Spark Igniter Plugs and Start Fuel Solenoid at 800°F (427°C) Tt7.		٠
المنافي المستعدد المس		
oil rressure (min 25,616); To (Max 510-0).		



Date:

Time:

Q-Fan Demonstrator

After Operation Inspection

	Operator	Engineer
Install Inlet and Exhaust Covers		
Visual Examination of Fan and Engine		
Check data taken during run		
Check log sheets - complete and correct		
Write up test engineer's log		

Comments:

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Q-Fen TM Demonstrator

Static Operation Check List

Date

The following items must be checked and signed for by the cognizant test engineer and rig operator <u>before</u> operating the fan pitch change actuator. Step 10 must not be performed prior to signing off the previous 9 steps.

		Operator	Engineer
1.	Stands clear of blades.	Augustjus (Indifferenta anne	
2.	Rear Spinner piloted and bolted in place.		····
3.	All instrumentation leads properly routed and tied down.	**************************************	
4.	Front spinner properly installed (if used).	Andrea and the second	
5.	Fan centered in duct (if duct installed)	<u> </u>	
6.	Blade angle feedback cable installed.		
7.	Blade angle control hooked up and working.	*	
8.	Scavenge pump on.		
9.	Personnel on stand notified.		
10.	Supply pump and transfer pump on and correct pressure set with relief valve.		

C-Fan Demonstrator **HSER 6700** Daily Log ENGLHEER DATE OPERATOR SHEET NO Two copies of this log are to be filled out by the responsible Test Engineer for each day's activity on the Q-Fan Demonstrator (One each to be filled at test rig and office). A - Check lists filled out as required Installation Check List Static Operation Check List Pre Run Check List Post Run Check List B - Run Time - This Date Total To Date Since Last Inspection C - Summary of Days Activity D - Problems Noted During Day -E - Corrective Action Taken -F - All Loose Hardware Removed From Stand & Covers In Place

231

SIGNED

- 7.0 Configuration Changes
- 7.1 Inlet Duct
- 7.1.1 Remove the inlet duct from the fan by removing MS16998-46 Screws (24) and AN960C416 Washers (24).
- 7.1.2 Install the inlet duct on the fan with MS16998-46 Screws (24) and AN960C416 Washers (24). Torque screws to 35-40 in 1bs lubricated and lockwire.
 - 7.2 Exit Duct (SK83424)
- 7.2.1 Remove the exit duct by splitting the duct. Remove MS16998-46 Screws (8), AN960C416 Washers (8), and MS21042-24 Nuts (8), (four per flange). Remove the MS16998-46 Screws (24) and the AN960C416 Washers (24) holding the two halves of the duct to the housing and remove the duct.
- 7.2.2 Install the duct in two halves. Bolt the two halves together with MS16998-46 Screws (8), AN960C416 Washers (8), and MS21042-24 Nuts (8), (4 per flange). Torque to 35-40 in-lbs., lubricated and lockwire. Line up marriage marks. Retain duct to housing with MS16998-46 Screws (24) and AN960C416 Washers (24). Torque to 35-40 in-lbs. lubricated and lockwire.
 - 7.3 Reverse Duct (222X-14)
- 7.3.1 Remove the reverse duct by splitting the duct. Remove MS21042-6 Nuts (8), 222X-14-3 Washers (8) and 222X-14-2 Studs (4). Remove the 69285-320 Screws (24) and the AN945-4P Washers (24) holding the two halves of the duct to the housing, and remove the duct.
- 7.3.2 Install the duct in two halves. Bolt the two halves together with 222X-14-2 Studs (4), 222X-14-3 Washers (8), and MS21042-6 Washers (8). Torque to 70-90 in-lbs. lubricated. Stud must be centered within .12. Line up marriage marks. Retain duct to housing with 69285-320 Screws (24) and AN945-4P Washers (24). Torque to 25-35 in-lbs. lubricated and lockwire

Sample Operating Sequence

(Coordinated Operation)

- 1. Perform the pre start inspections and procedures per sections 3.4 and 3.5
- 2. Connect the teletype to the computer per section 4.7.
- 3. Call the LI option in the computer program and list the parameters in the program for reference. Reference section 4.8.2
- 4. Call the HO option in the computer program and change parameter values for the desired test program. Reference section 4.8.4.
- 5. Start the fan per section 3.6.
- 6. With the fan at ground idle in the "MANUAL" mode, press the idle button on the idle/failsafe panel. Reference section 4.9.
- 7. With the fan at ground idle in the "IDLE" mode press the "AUTO" button on the idle/failsafe panel. The fan will increase power to flight idle. Reference section 4.9.
- 8. The programmed transient can now be checked out per section 4.8.5
- 9. Call the SE mode, reference section 4.8.6., and using the thrust setting potentiometer set the beginning point of the desired transient. Reference section 4.9.
- 10. Call the RU mode, reference section 4.8.7, and using the thrust setting potentiometer, perform the transient.
- 11. Call the SE mode, and return the fan to flight idle with the thrust setting potentiometer.
- 12. Leave the SE option. Reference section 4.8.6.
- 13. Changes to the program as necessary for the next planned transients can now be made, checked out, and run per steps 4,8,9,10, and 11. Steps 12 & 13 can be repeated for all of the desired test conditions.
- 14. To leave the AUTO mode, set the thrust setting potentiometer for idle, and press the "IDLE" button on the idle/failsafe panel. The fan will decrease power to ground idle.
- 15. Press the "MAN" button on the idle failsafe panel.
- 16. Shutdown the fan per section 3.9.

17. Ferform the after operation inspection per section 3.11.

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APPENDIX F

TEST RESULTS

Tabulation of Manometer Photographs - The enclosed data sheets are listings taken from the photographs of the manometer banks during the reverse thrust performance testing.

рното но			TEST DATE	5-2-		ANALYSIS N			
	TAP "	PROSS (<i>ABR#</i>)	TAP	PRESS (ABR#)	TAP //	Press (<i>Abr+</i>)	TAP	PPISS (<i>ABRY</i>)	
-	1	-7./	, 26	-6.1	51	REF.	76	REF.	
	2	٥	; 27	-6.7	52	-6.0	77	0	-
	3	0	, 28	-7.7	; 5 3	0	78	0	•
	14	-5.8	29	-7.0	54	2	79	0	
	5	0	30	-7.4	55	-11.6	: 80	0	
	6	0	31	0	56	-7.5	, 81	. 0	
	7	0	. 32	-5.6	57	-3.2	: 82	0	-
	8	-7.6	; 33	, 0	; 58 °	/.3	: 8 3	0	
	9	-7.6	34	-4.5	59	0	84	. 0	
	10	-7.7	35	-6.3	60	4	85	0	
	11	-7.3	36	-5.5	61	3	86	ं	
_	12	-7.5	37	-8.5	62	2	87	0	
=	13	0	38	-7.7	, 63	-,3	. 88	0	
	14	0	39	-7.2	64	4	89	10	
•	15	0	40	-7.0	65	0	. 90	: 0	
	16	0	41	-7.2	66	5	91	-/3.2	
•	1 17	0	ļ 42	-7.2	67	3	; 92	4	
· · ·	18	0	43	- 8,8	68	5	93	-5.5	
*	19	-8.3	44	-7.5	69	-,4	ÒĦ Ž	-10.7	
	20	0	. 45	-7.7	70	4	95	!/	
ŧ	21	-7.4	46	0	71	2	96	-11.2	
· · · · · ·	55	_ 4.8	47	- 5.7	72	4	97	-/3.2	
de.	23	-7.6	148	-7./	73	/	98	0	
	54	-6.7	149	-9,2	74	-,2	. 99	. 0	
	25	-8.7	50	-7.2	75	0	100	-/2.7	
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Q-MATE PROTEST AND	

PHOTO NO	TAP /	PFESS (ABR4)		PAP	PRESS (ABN4)		TAP /	Press (<i>fbr4</i>)		TAP (O. "(PRESS (<i>MBRY</i>)	
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•	1	0	i	27	-8.2	1	52	-7.5	ļ	77	-1	
	3		i	.58	-9.4	į	53	0		78	2	
	1 .	1	ļ		-8.4		5.∔	2	·	79	2	-
	4	-7.3	1	59	-7./	İ	55	15.4	İ	80	2	
	5	0		30 31	0		56	10.0	į	81	/	
	į	0	Ì		-4.2		57	4.6	i	82	1	
	7	1	i	35	0	į	58	2.1	1	83	/	
· · · - · ·	8	-9.4		33	-5.1	İ	59	.4	ļ	84	/	
	9	-9.6		34	-7.6		60 60	3	į	85	/	
	10	-9,8		35	1 1	į		4	1	86	/	
	11	-9.2		36 27	-6.1	1	61.	5	İ	87	/	•
- · -	12	-9.5		37	-10.7	! !	6R	-,5	· •	88	/	
	13	0		38	-9.7	į	63 64	-,6		89	/	
	14	0		39	-8.9		,	/			/	
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	17	0		42	-9.0		67	1		92	-6.7	
	18	•		43.	-//.0		68	8 7		93	-12.6	 i
	19	-10.6		44	- 7.2	!	69	1		94		1
	50	0		45	-9.6	 	70	6		95	-14.0	: }
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	18	0	43	-8.9	68	-,4	93	-4.3	
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	50	0	45	-7.8	70	2	95	/	:
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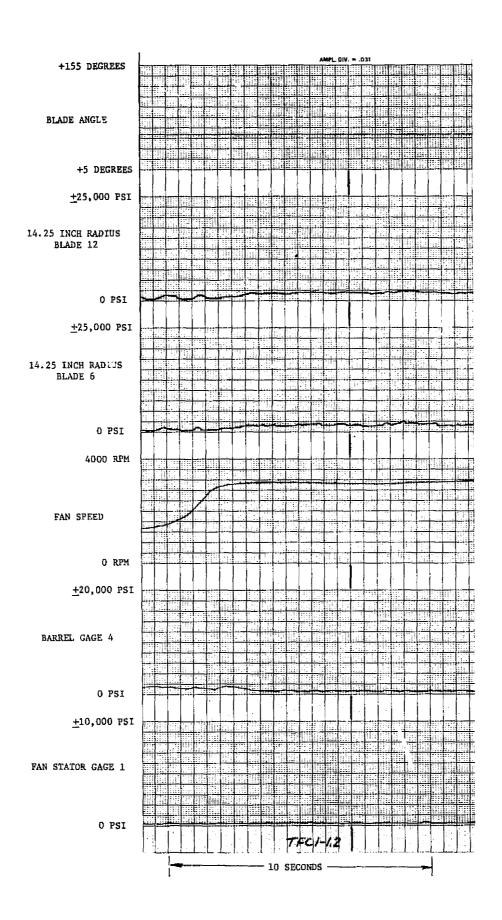
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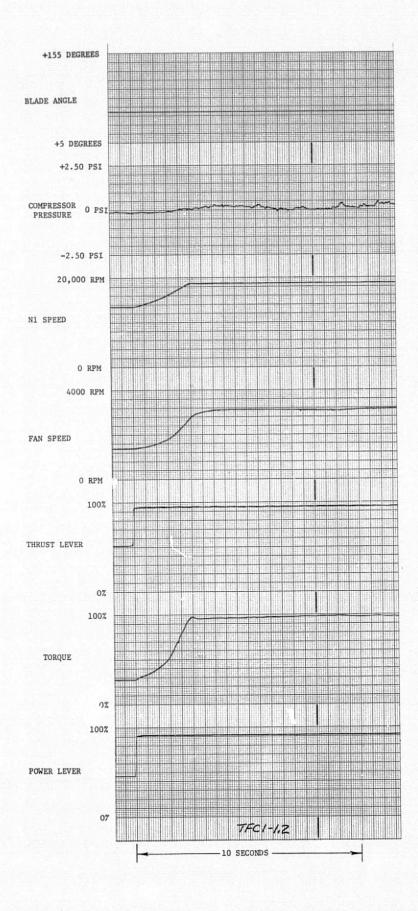
Samborn recordings - The following are Samborn recordings of various parameters taped during the performance of the transient test program at the Hilltop facility of Hamilton Standard. Figure 76 is a blade angle calibration curve to be used in conjunction with all of the Sanborn recordings. A study of the curve illustrated in Figure 54, "Comparison of Sanborn and Visicorder Traces" and the discussion in Section 5.1.2.2 reveals that the discharge time constant of the peak converters used to develop the Sanborn data prolonged the return of the stress values to zero. Inspection of all Sanborn stress data illustrates this phenomena; note that although the increasing rates of stress versus time vary from run to run, the rates of stress decrease are all exactly the same due to the discharge time constant. Thus, if the actual transient elapsed time is required, the Visicorder trace of the transient of interest is a much more sensitive and accurate indicator of response time. Since the value of the stress peak and the character of the stress response both determine the elapsed time required for the Sanborn stress to return to zero, it is not possible to determine a factor which could be used in conjunction with the Sanborn data to establish actual transiest response times.

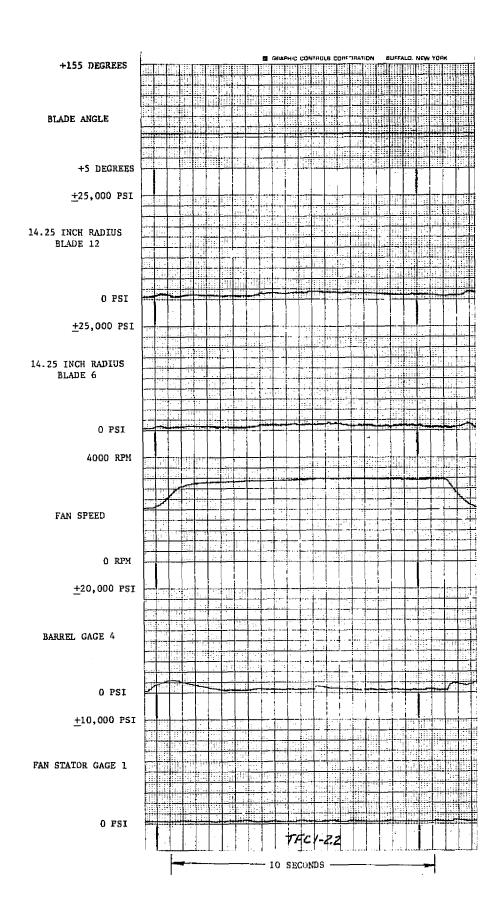
The parameters illustrated on the Sanborn traces are Blade Angle, Blade, Barrel, and Vane stress, Fan Speed, Compressor Face Dynamic Pressure, N_1 , Speed, Thrust Lever Position, Torque, and Power Lever Position.

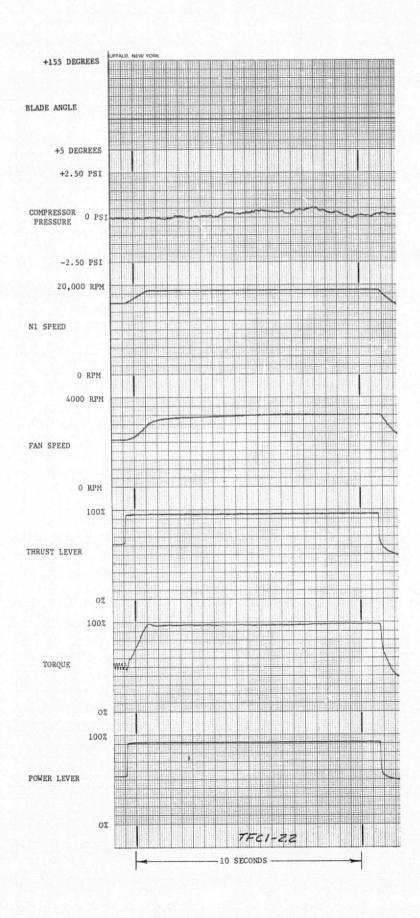
Forward Thrust Transients - The following are Sanborn recordings of various parameters taped during the performance of the forward thrust transients (TFC) at the Hilltop facility at Hamilton Standard.

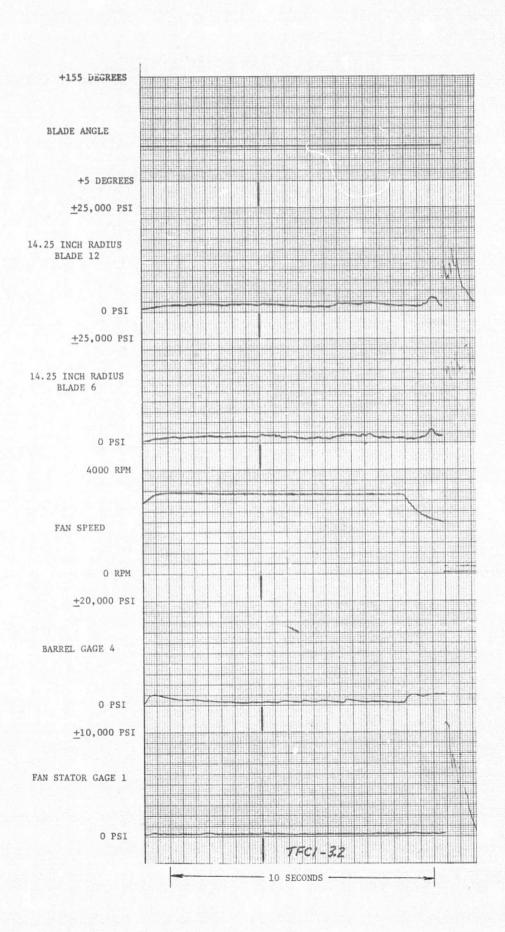
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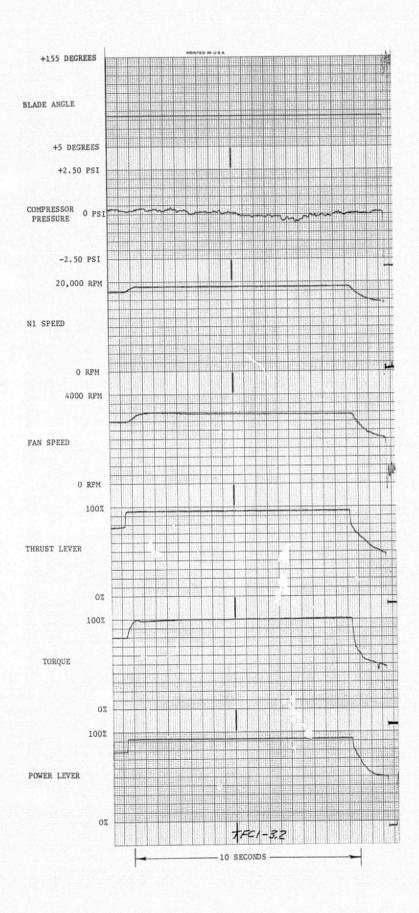


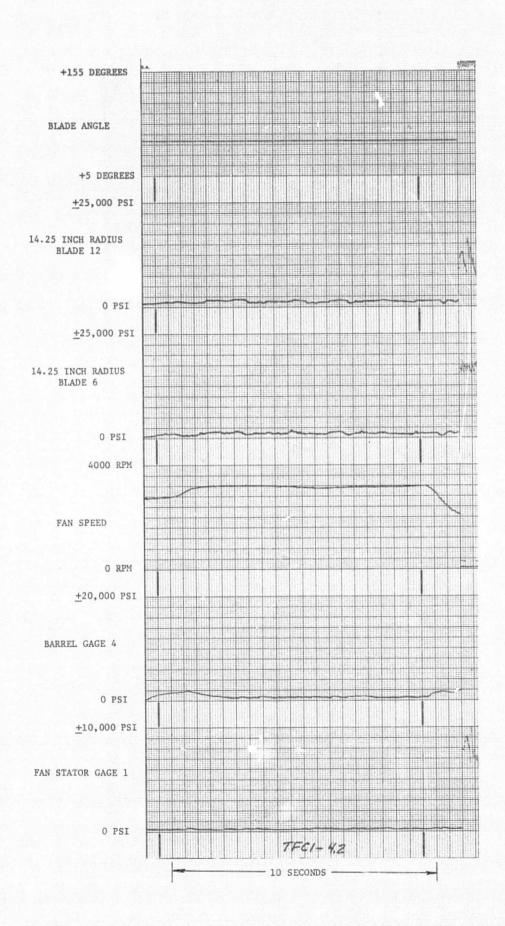


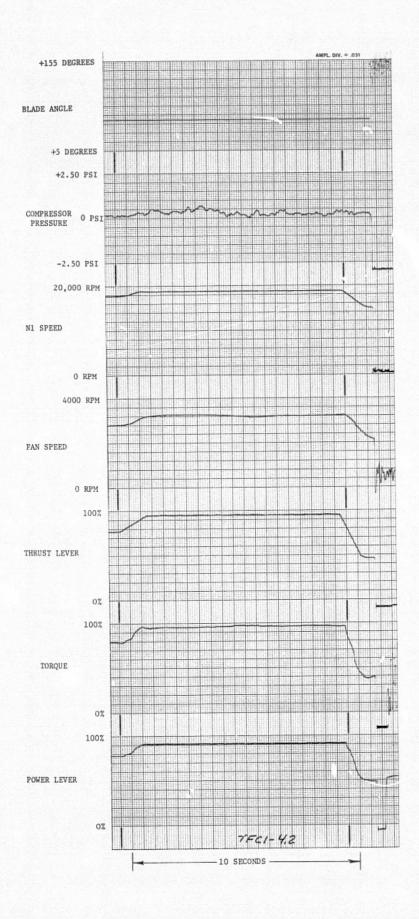


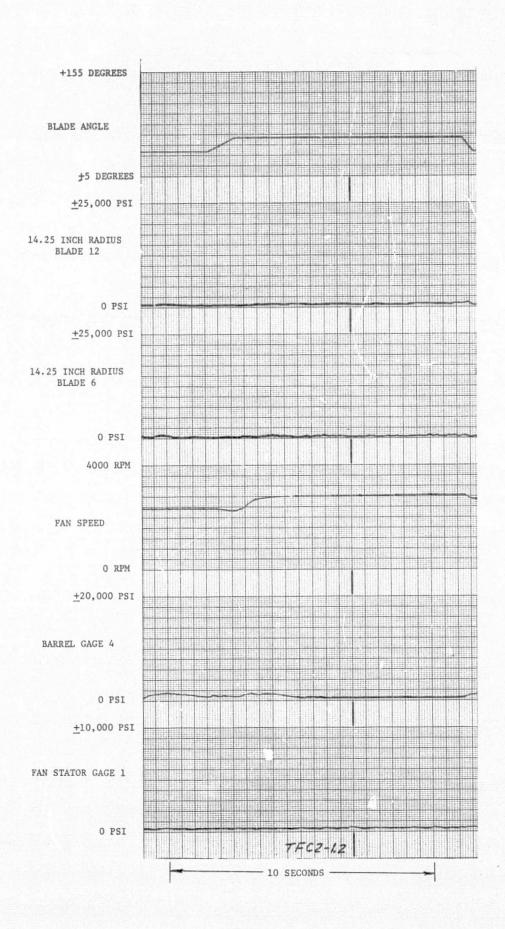


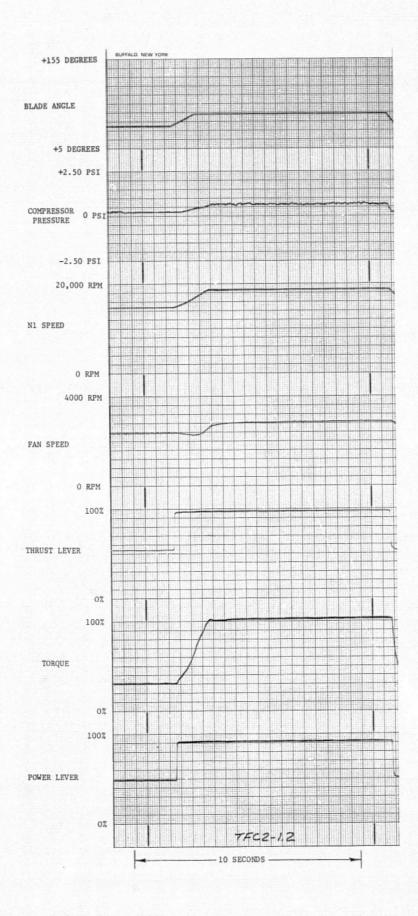


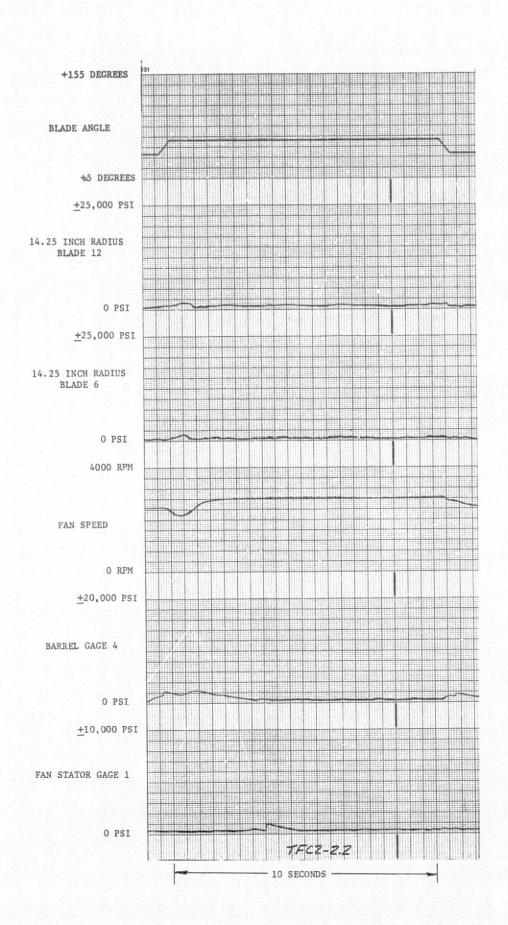


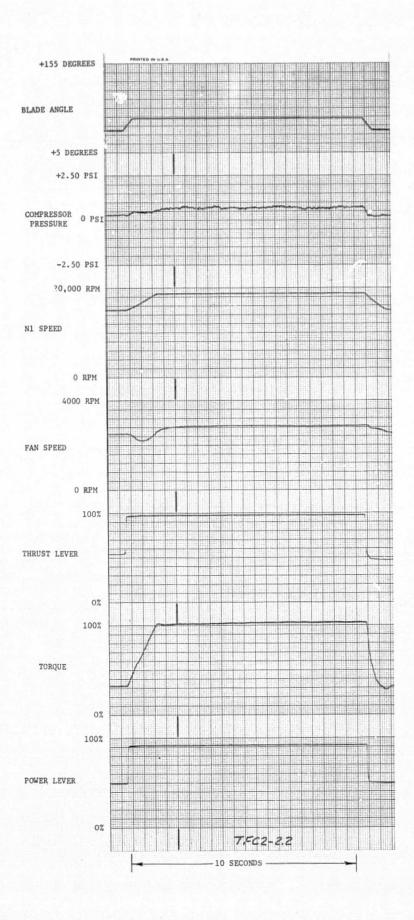


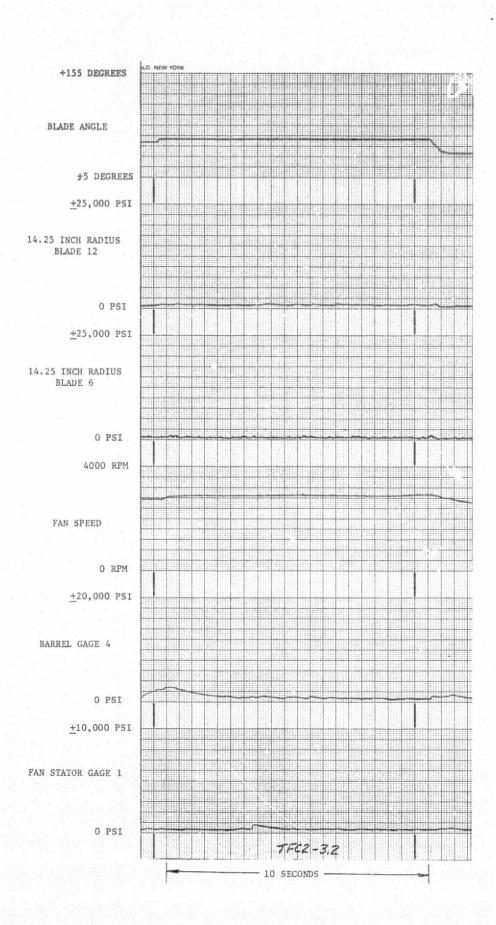


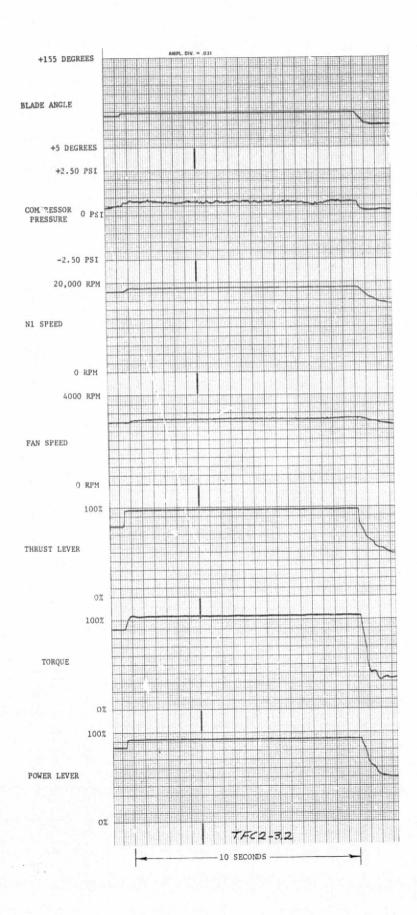


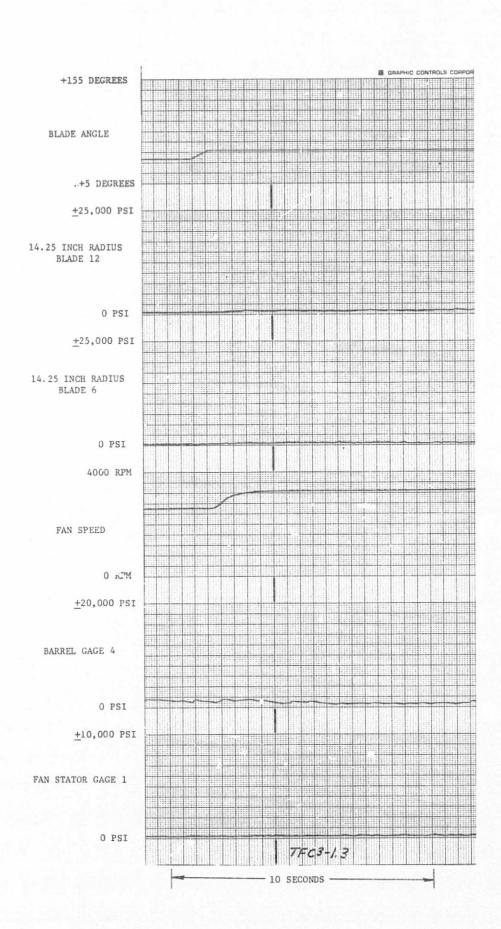


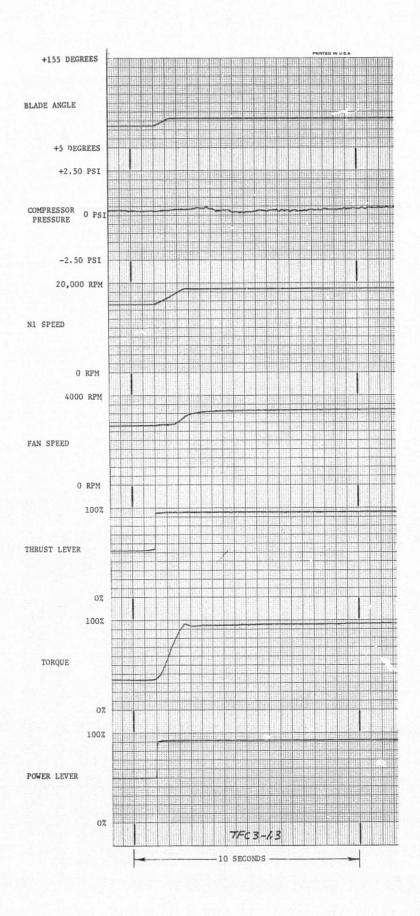


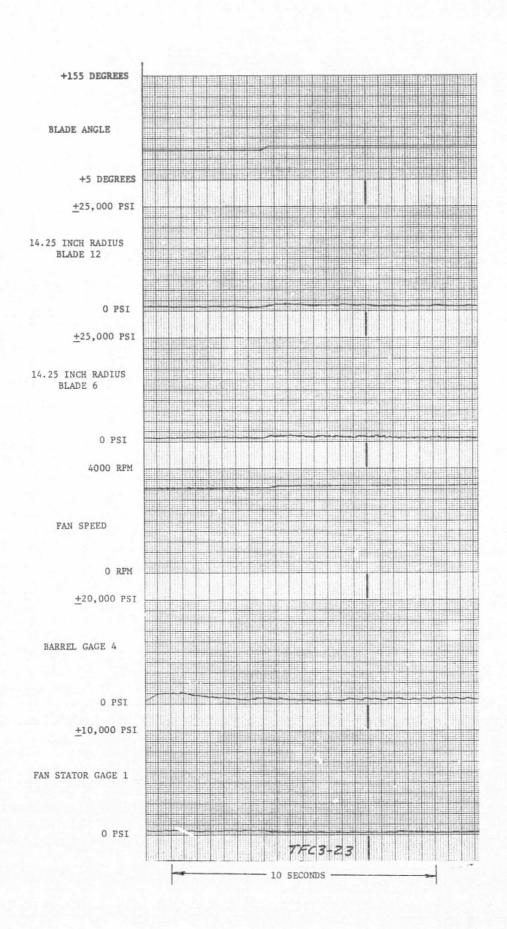


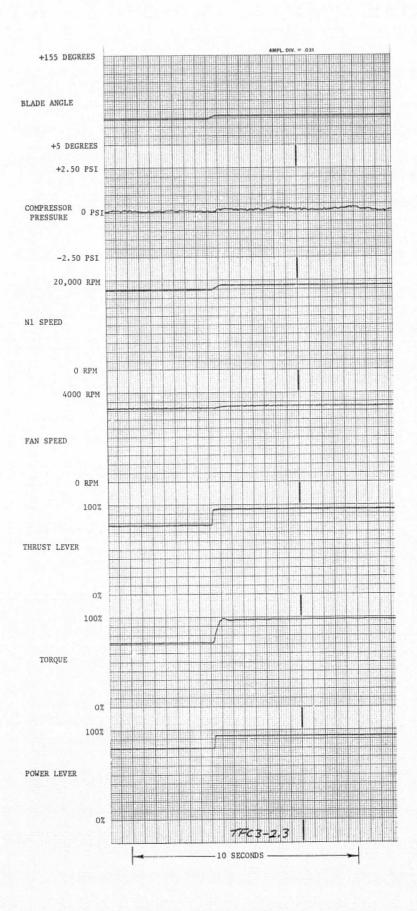


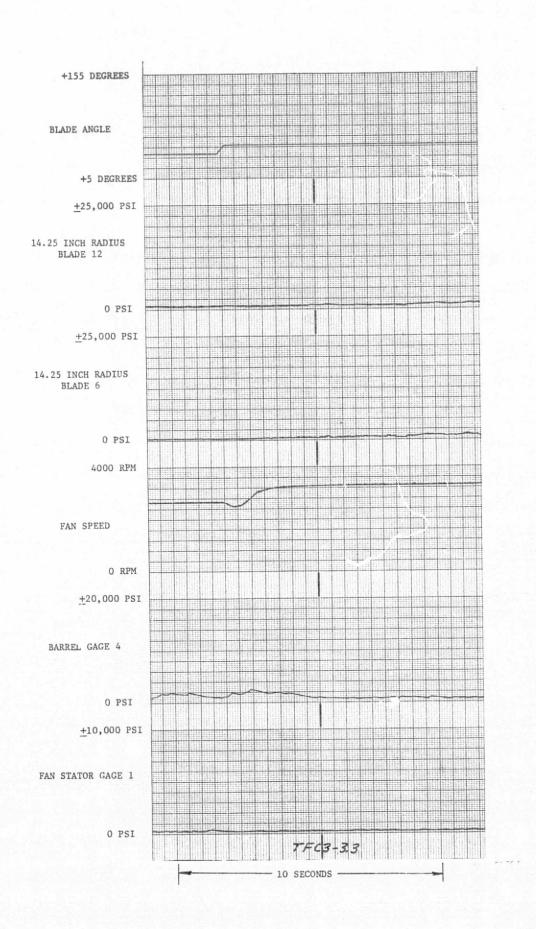


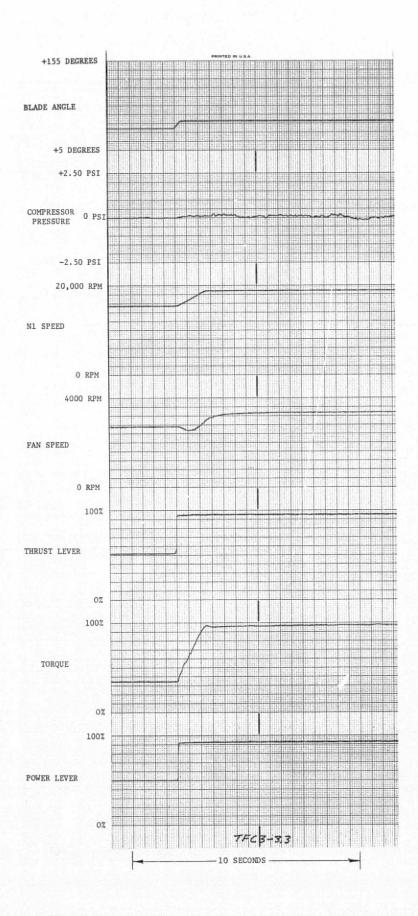


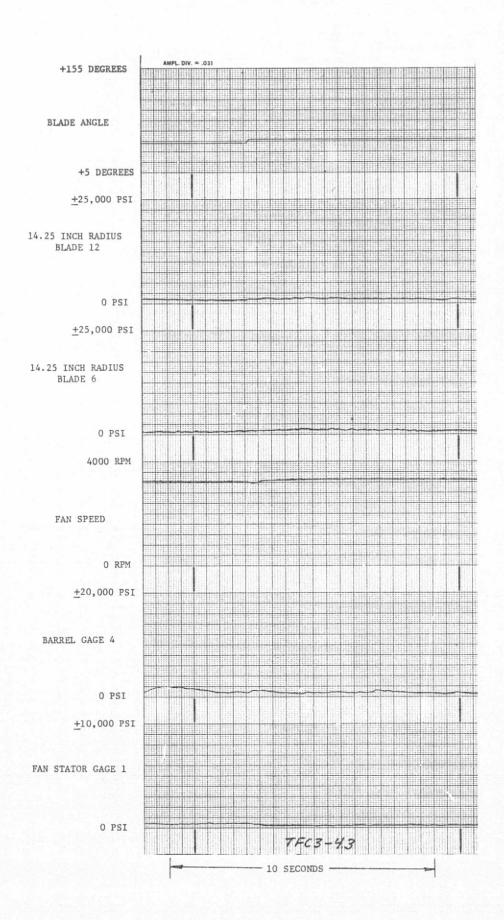


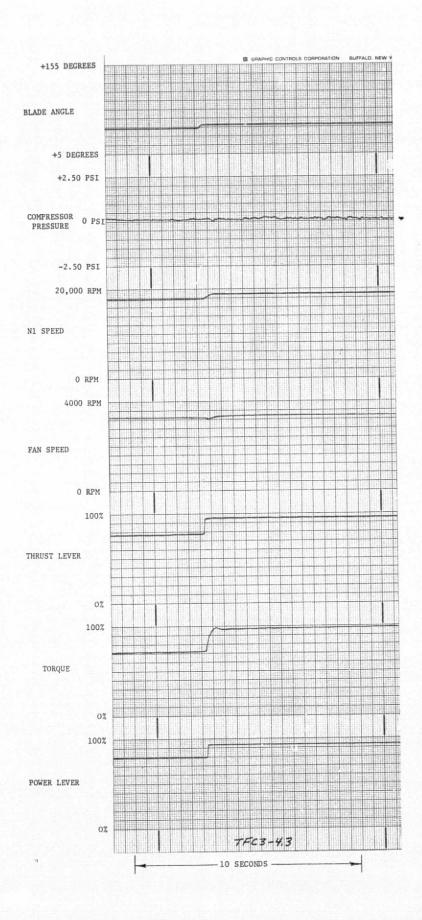


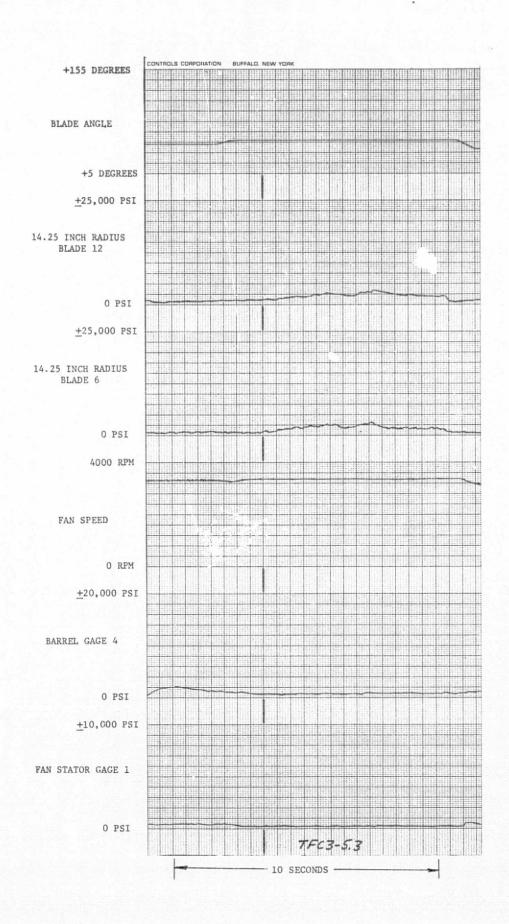


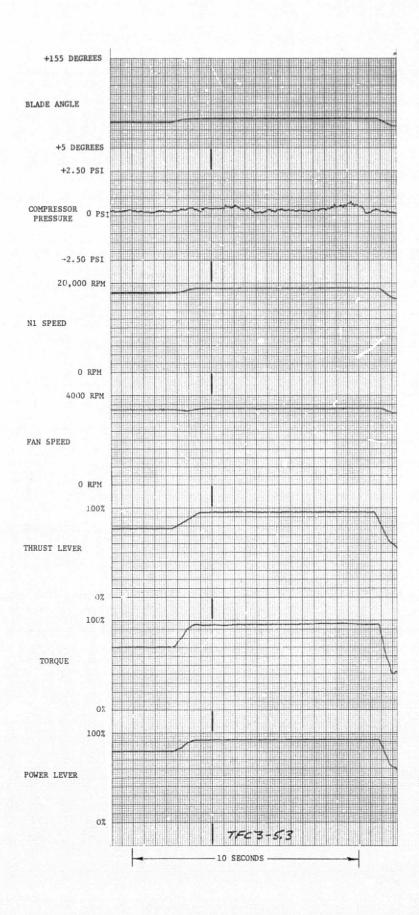


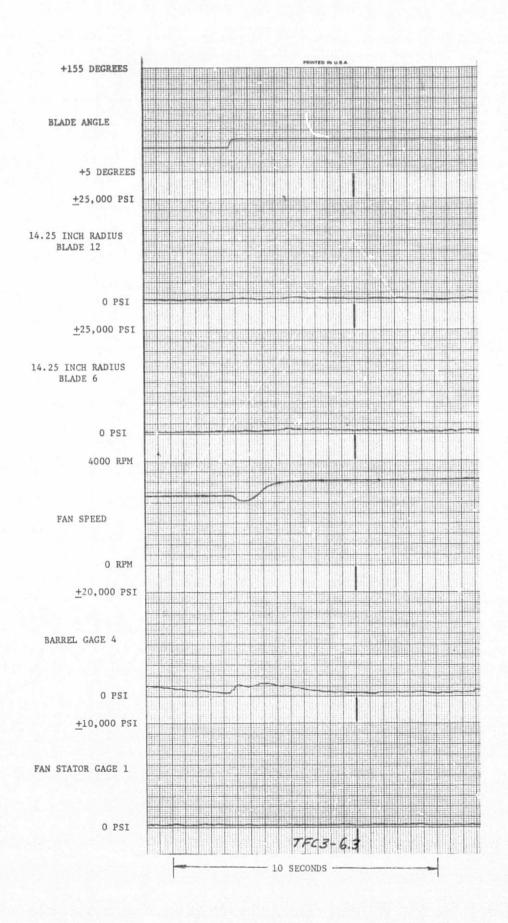


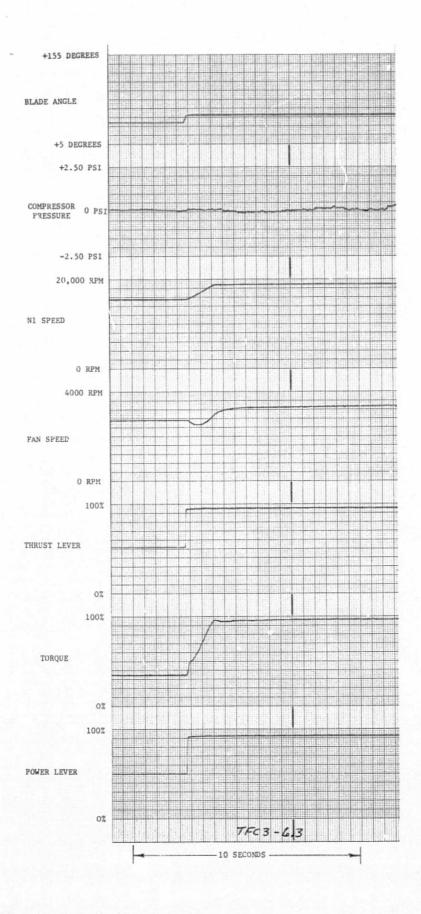


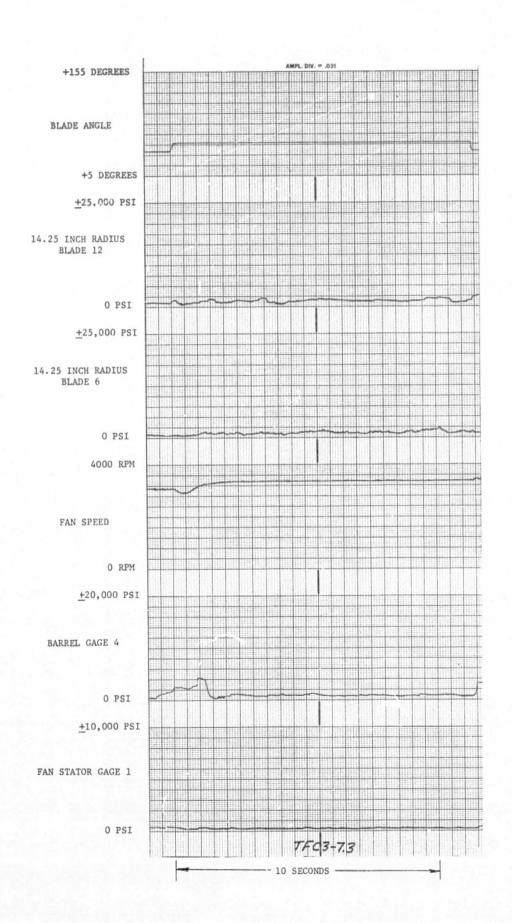


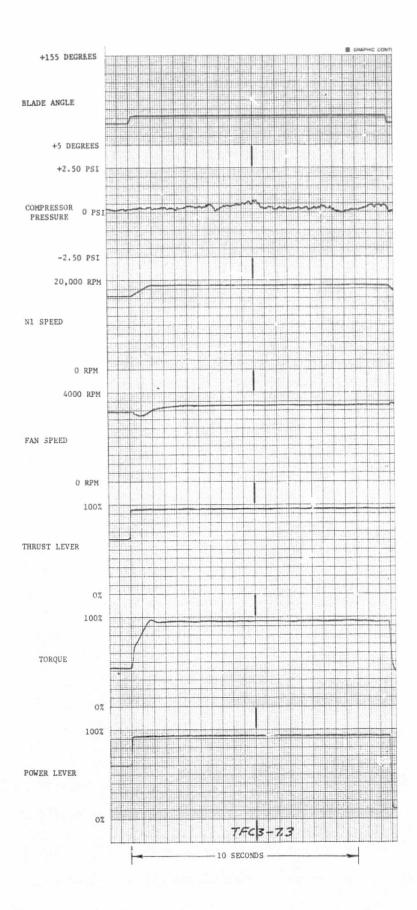


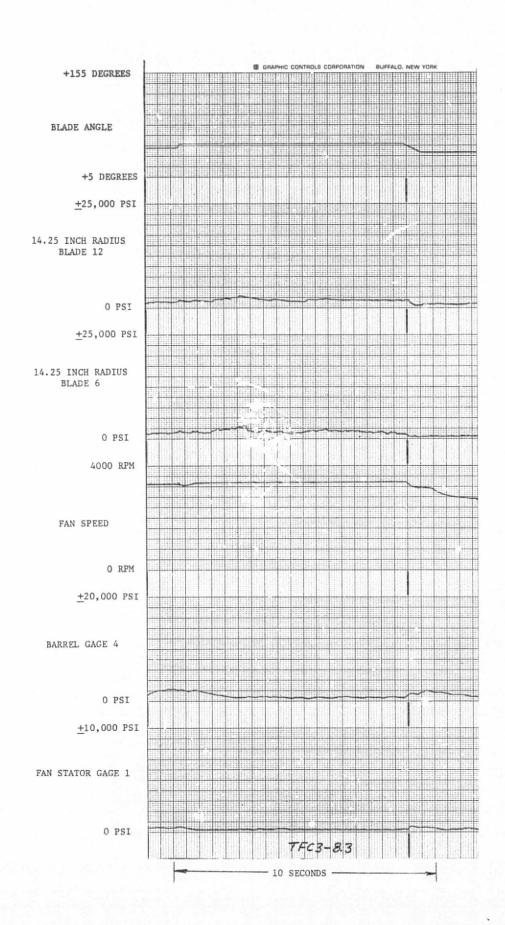




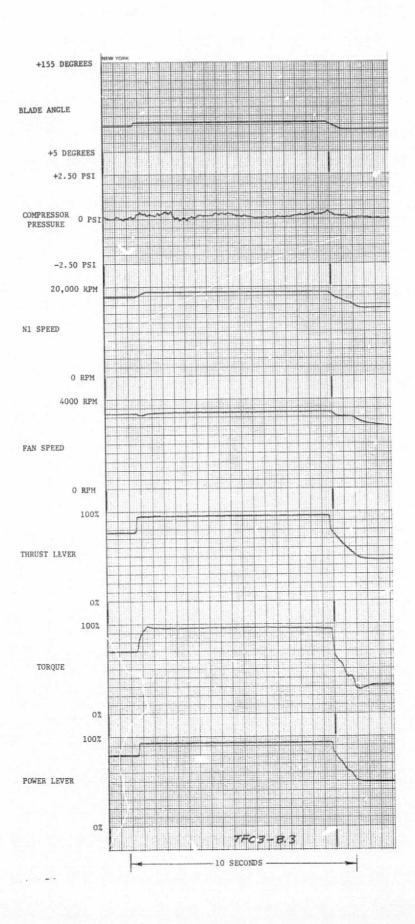


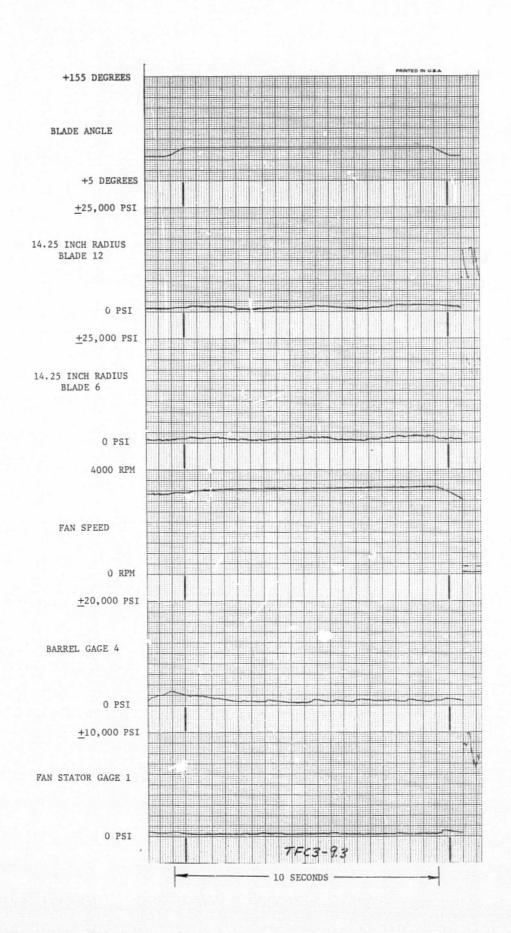


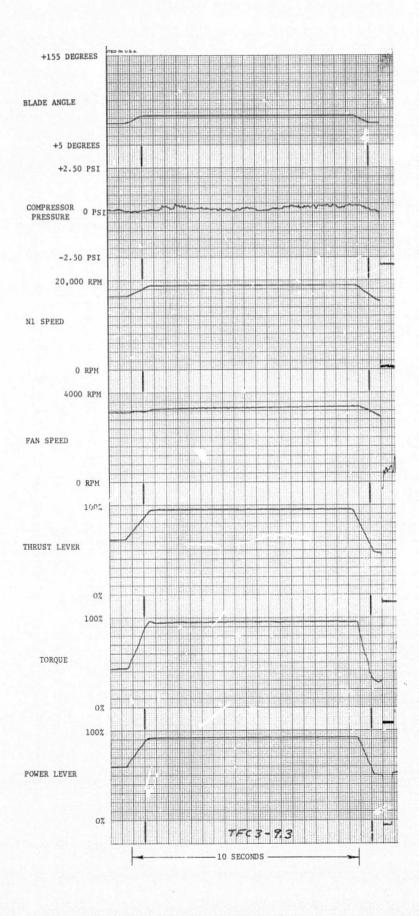


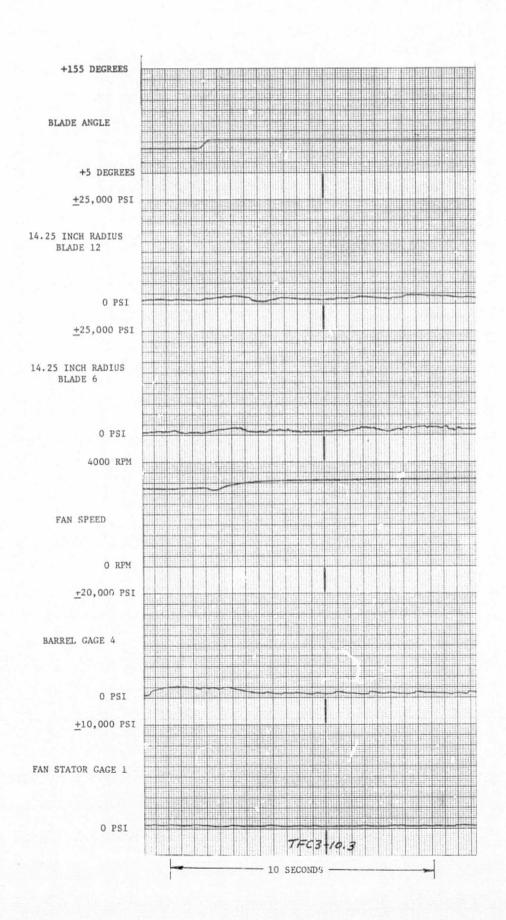


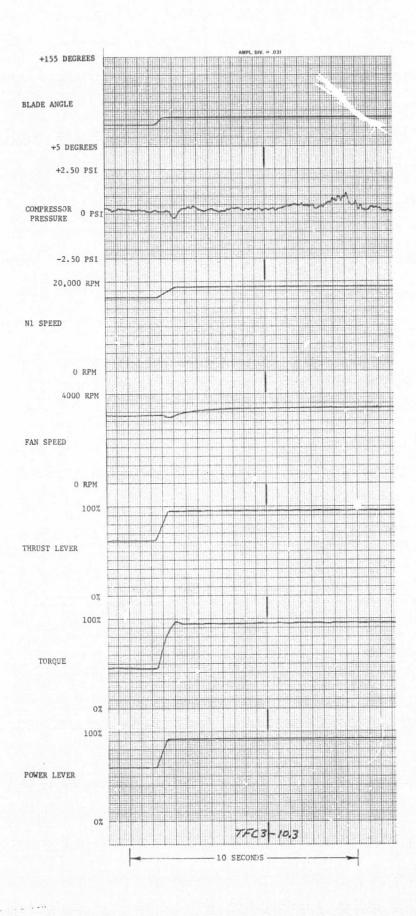


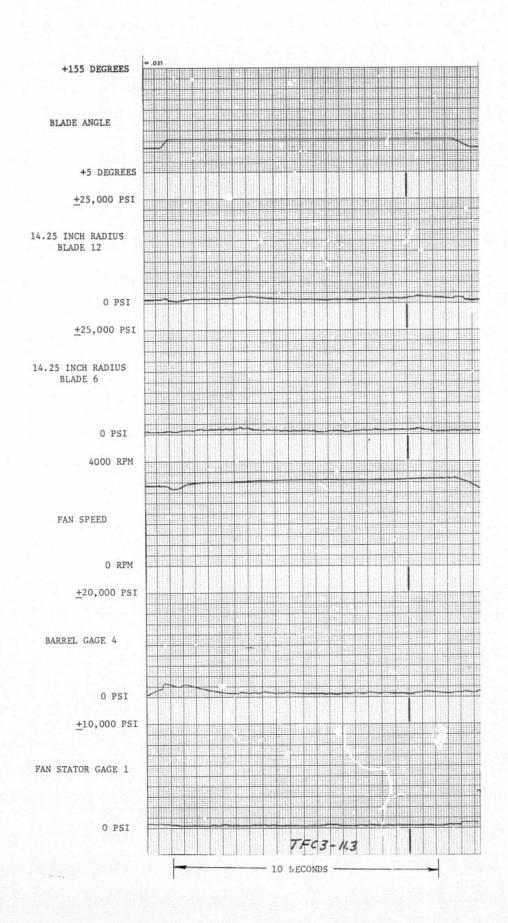


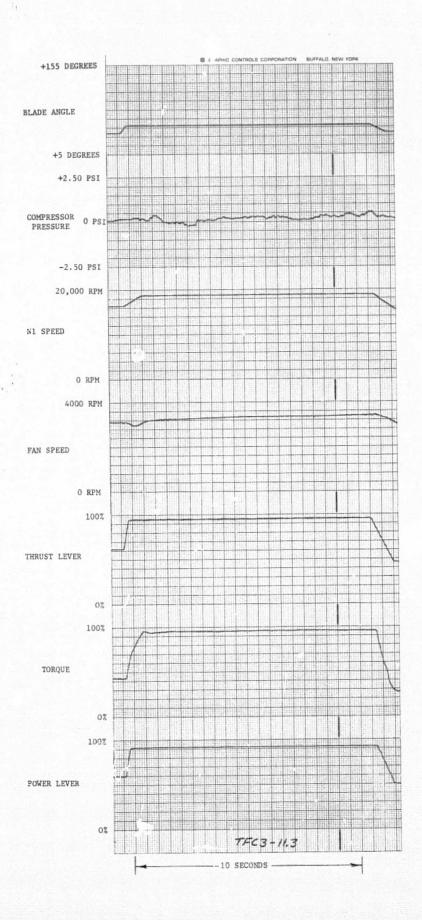






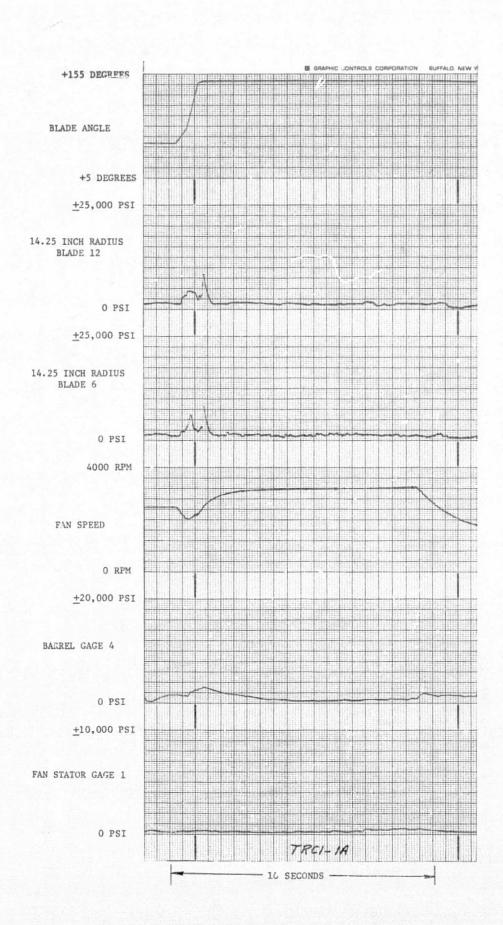


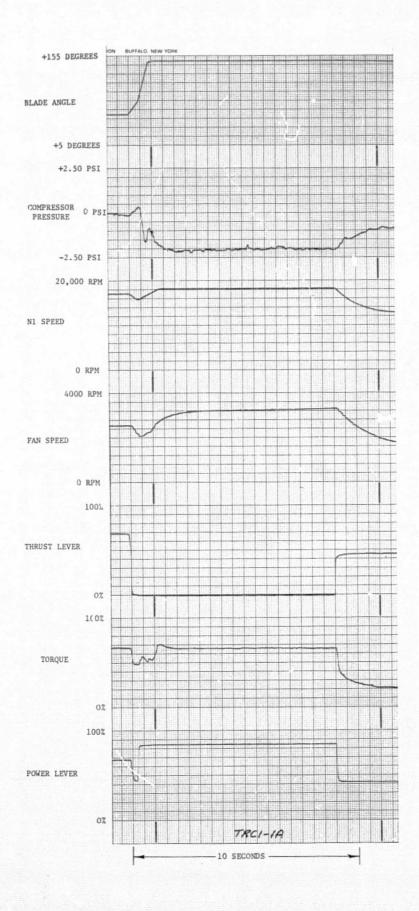


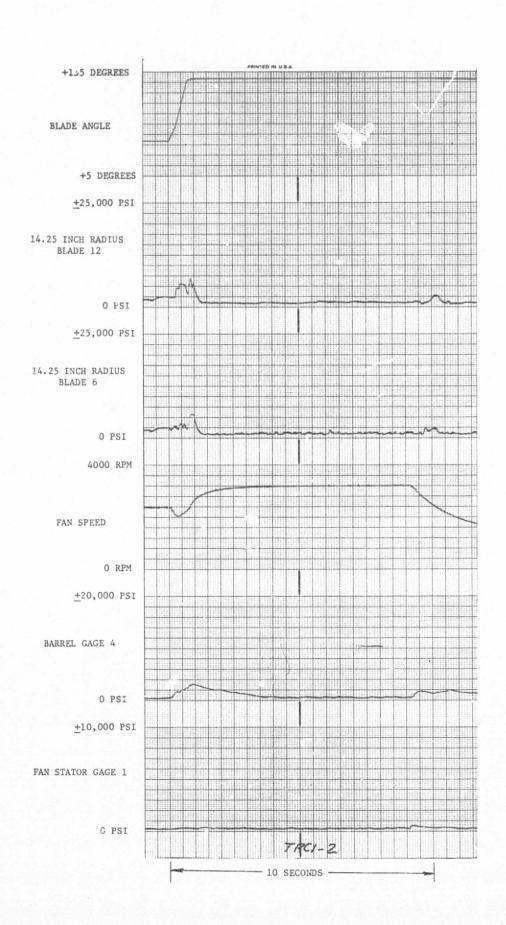


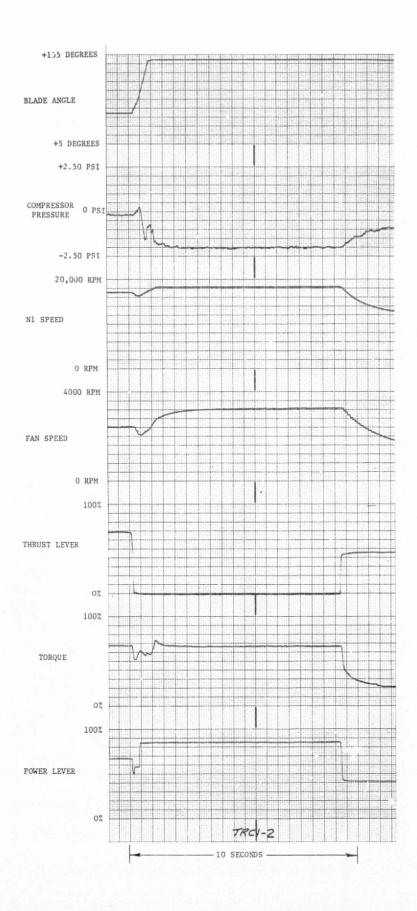
HSER 6700

Reverse through Feather Transients - The following are Sanborn recordings of various parameters taped during the performance of the Reverse through feather transients (TRC) at the Hilltop facility at Hamilton Standard.

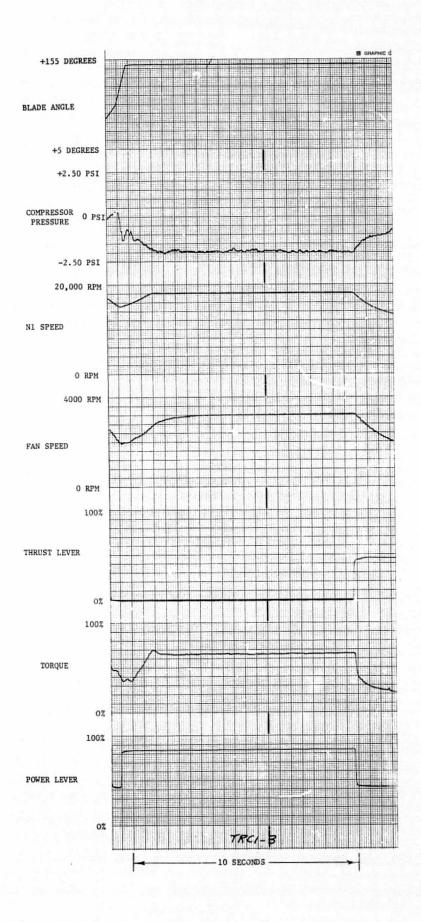


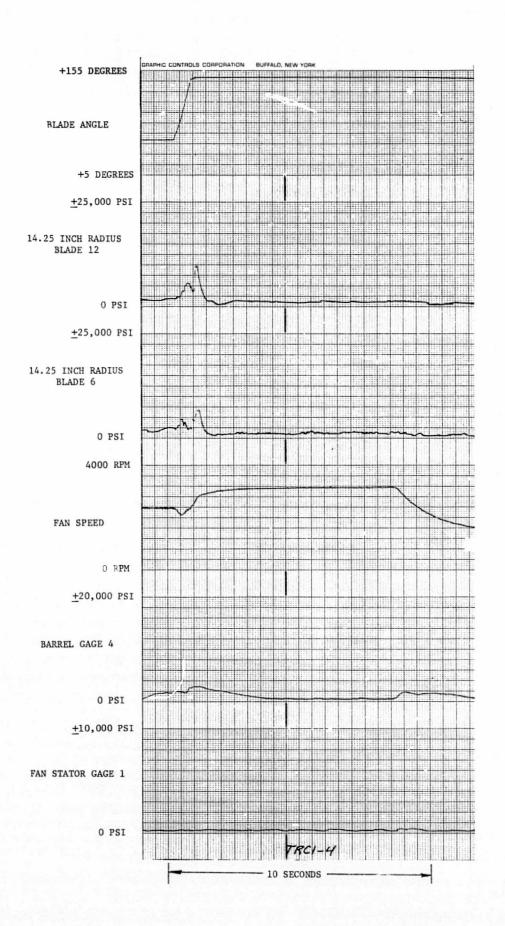


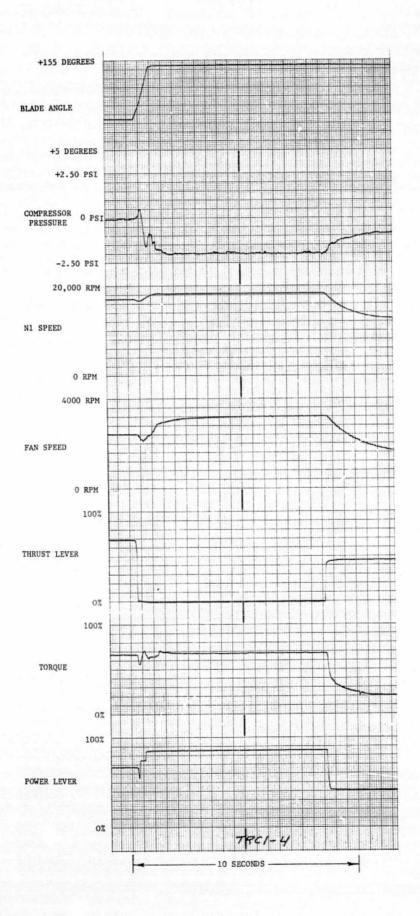


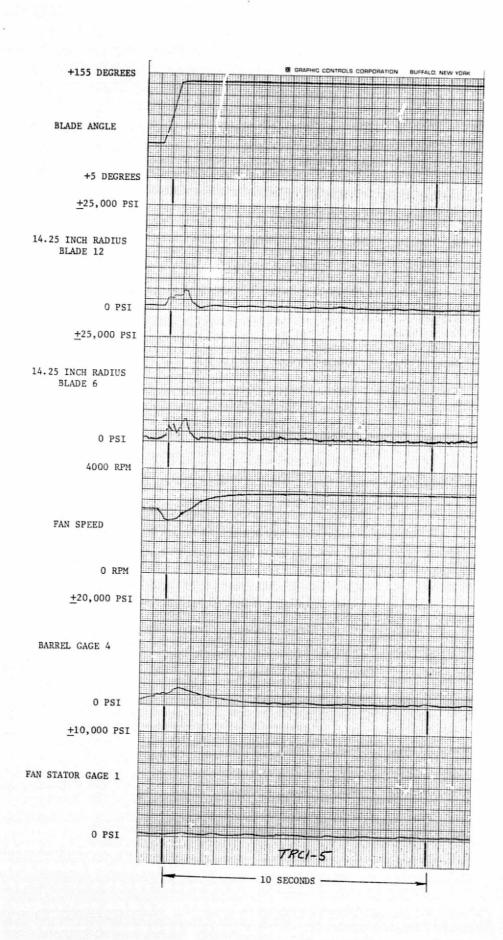


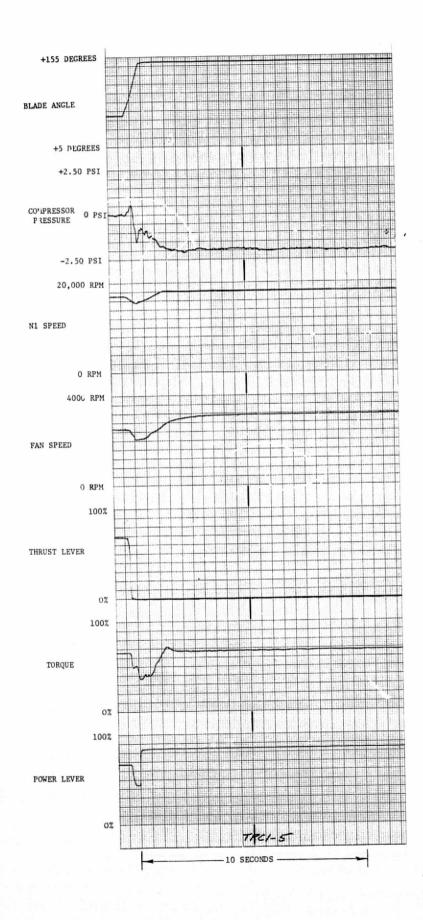


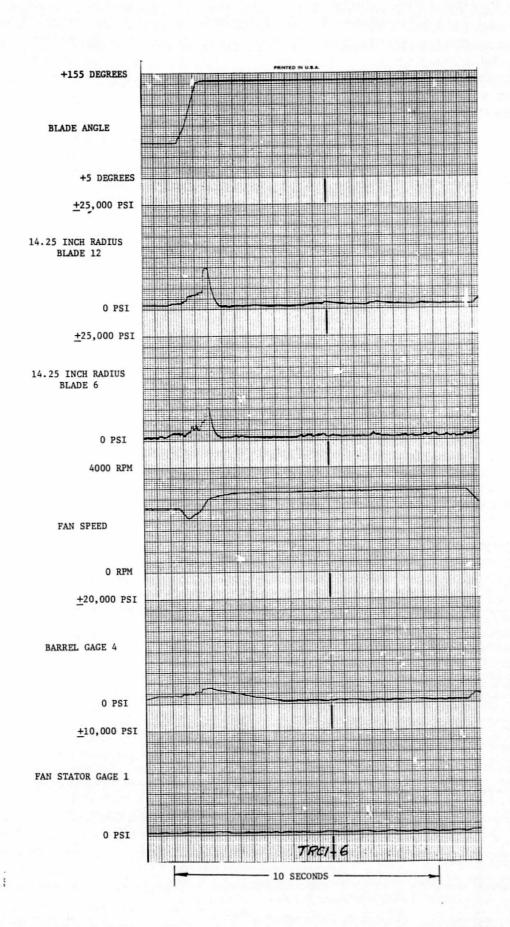




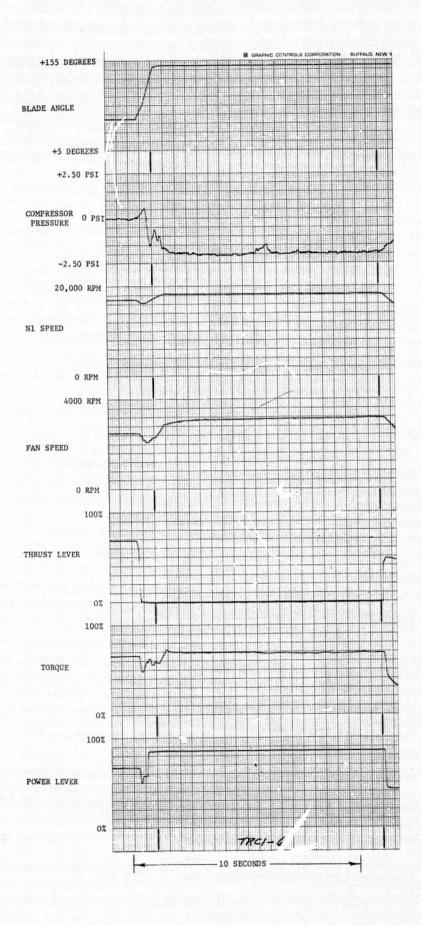


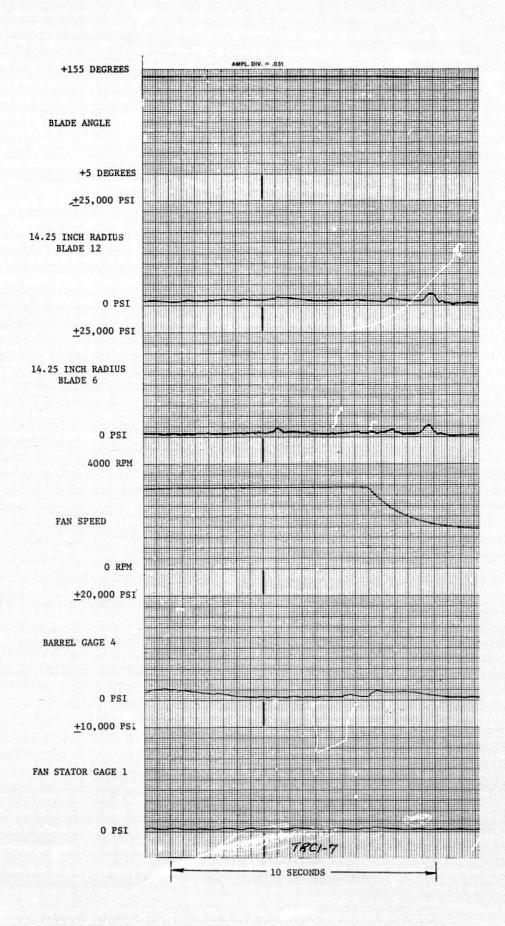


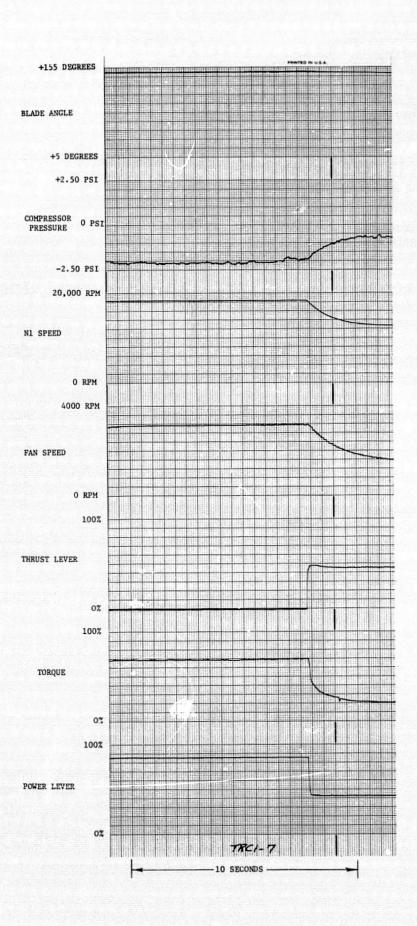


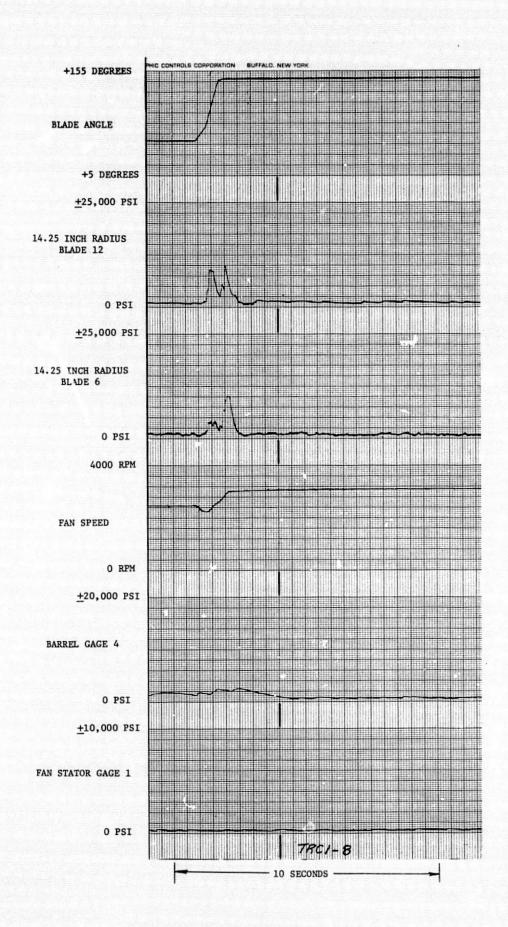


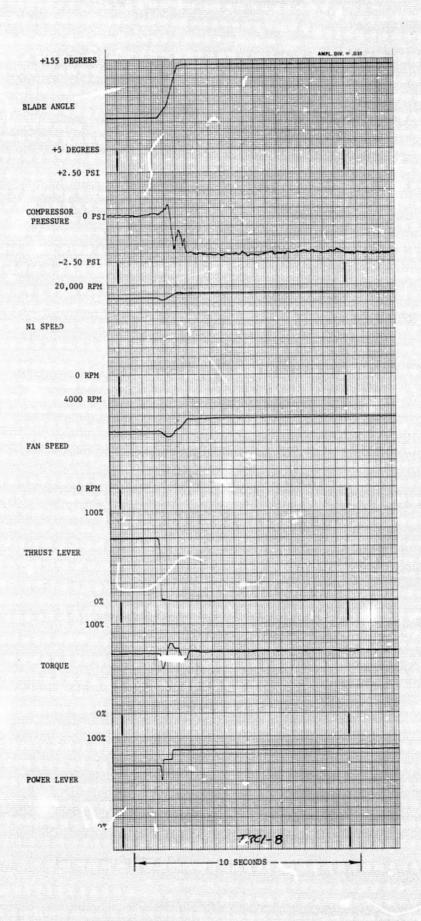


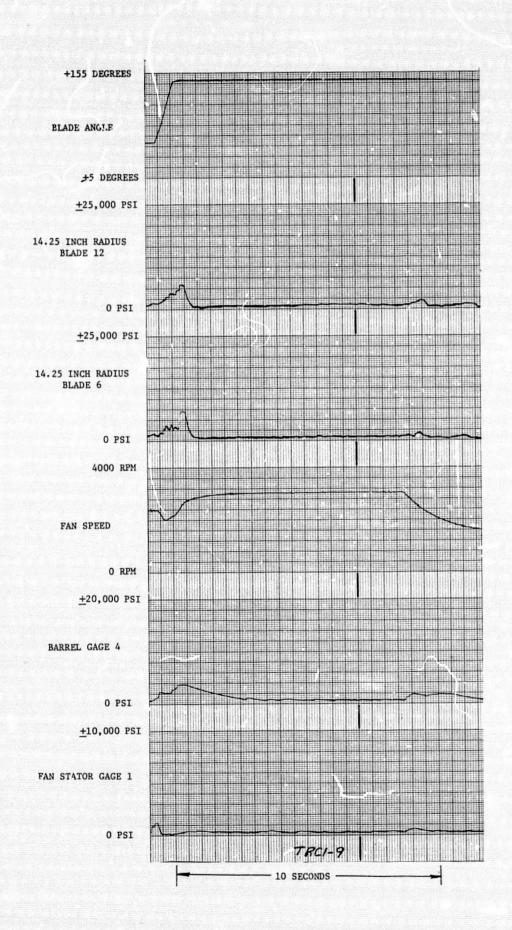


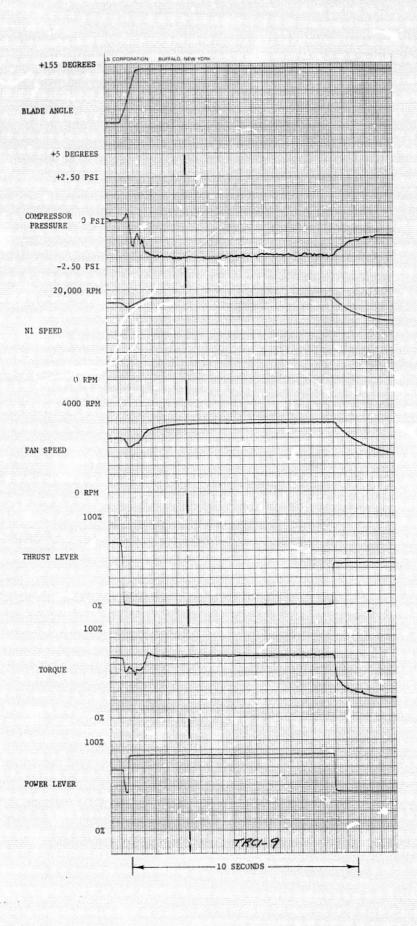


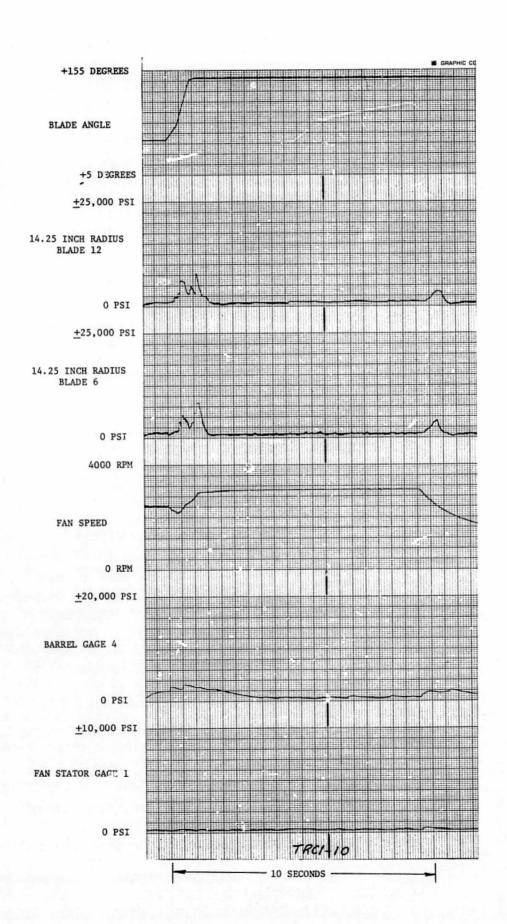


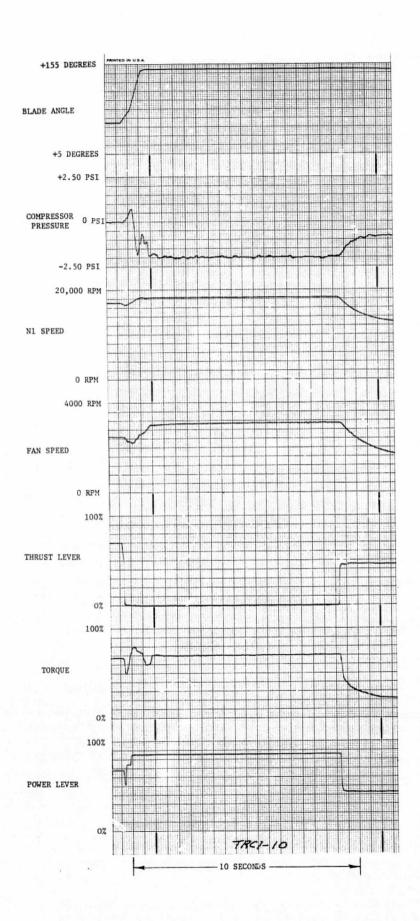


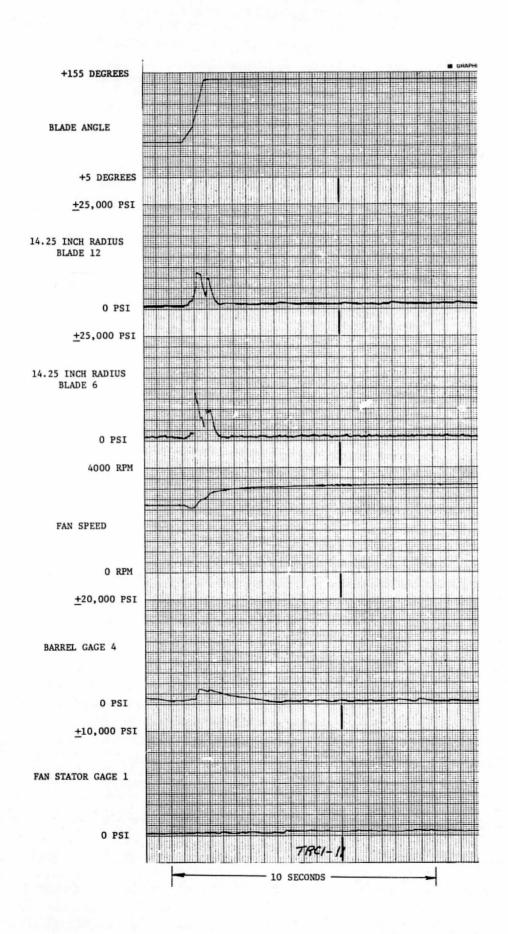


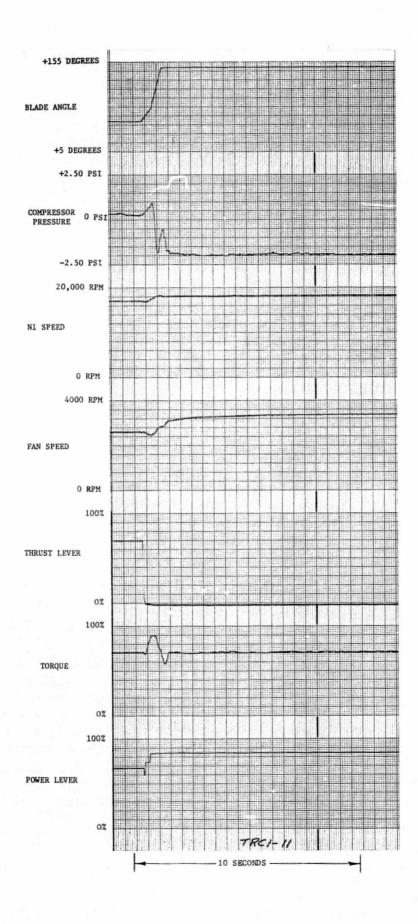


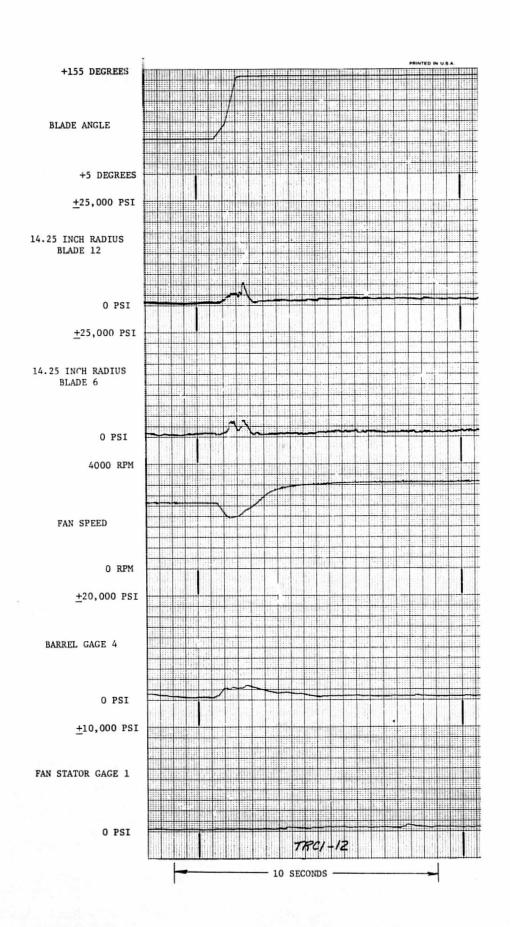


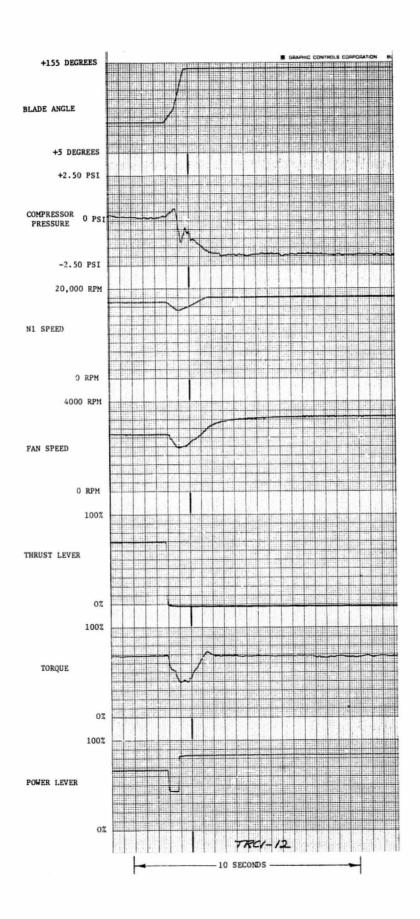


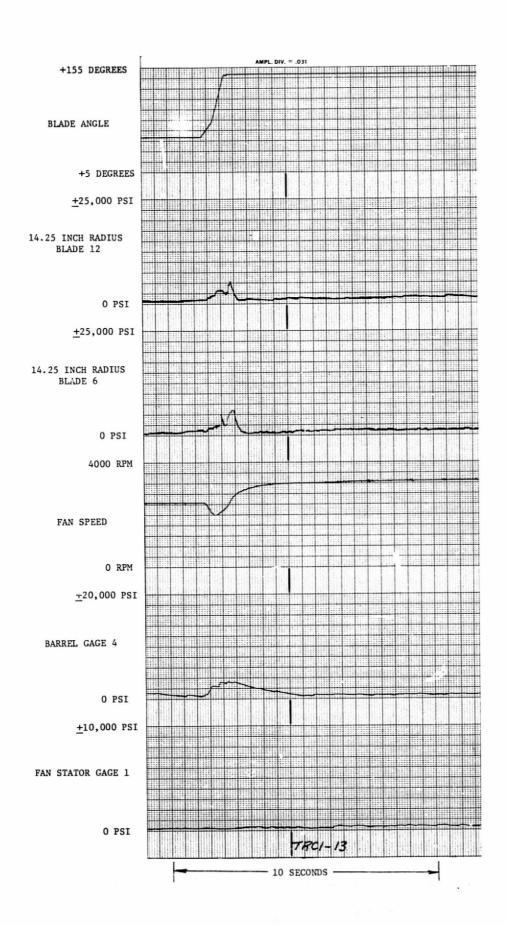


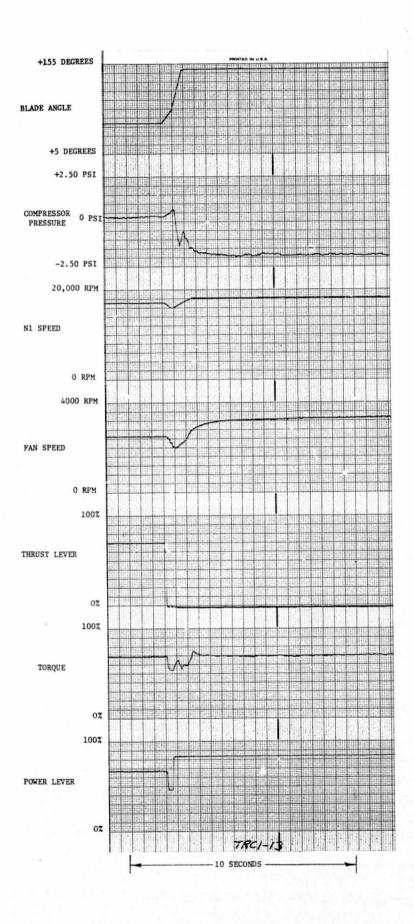


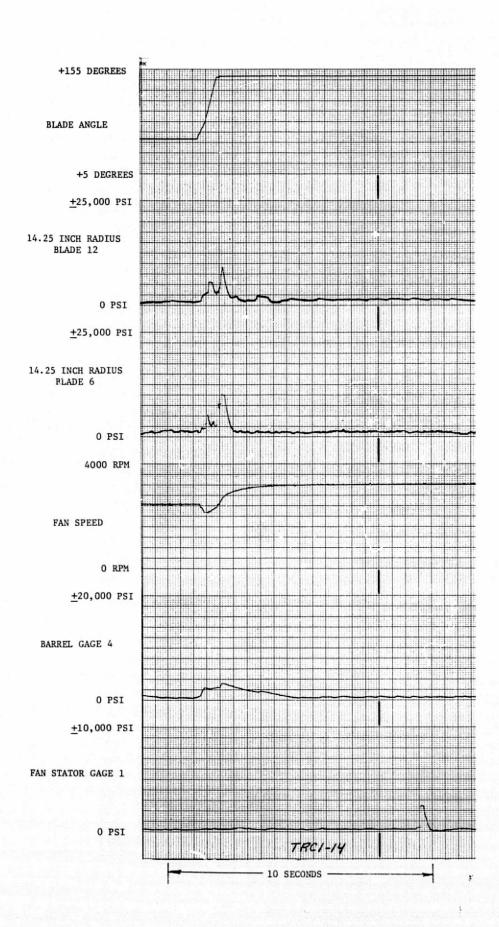


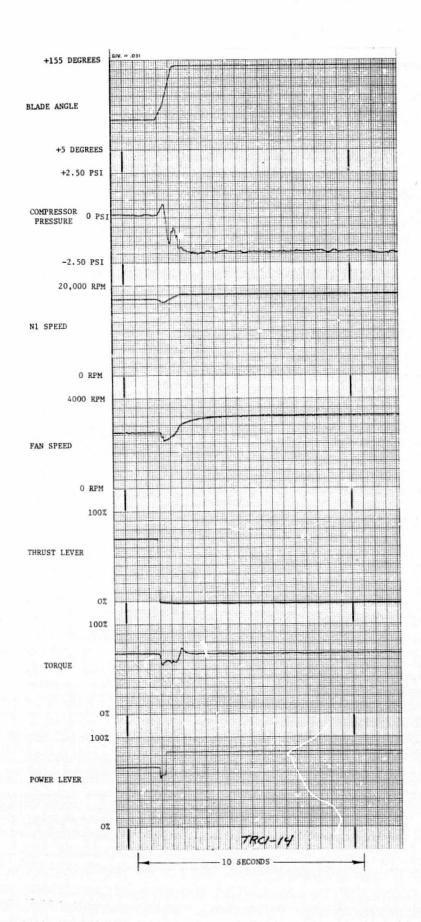


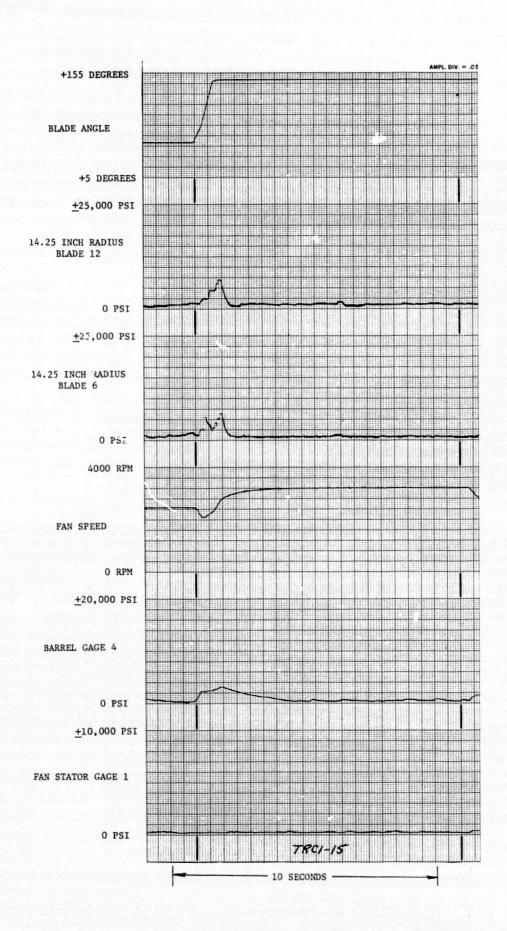


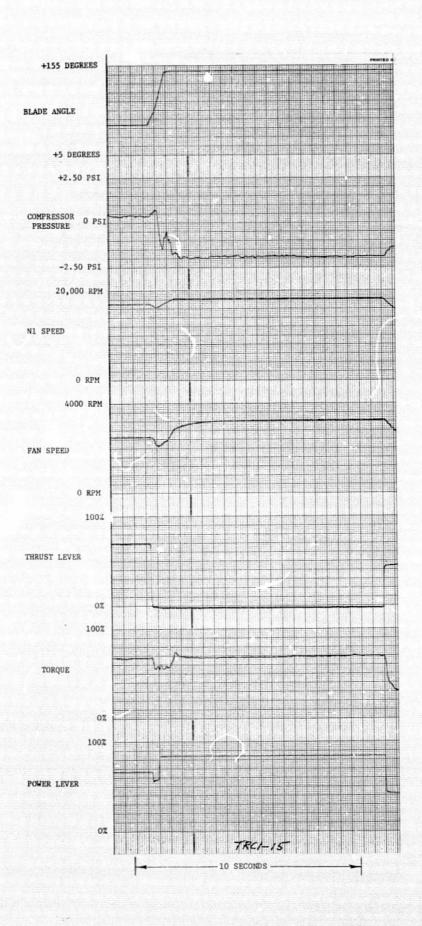


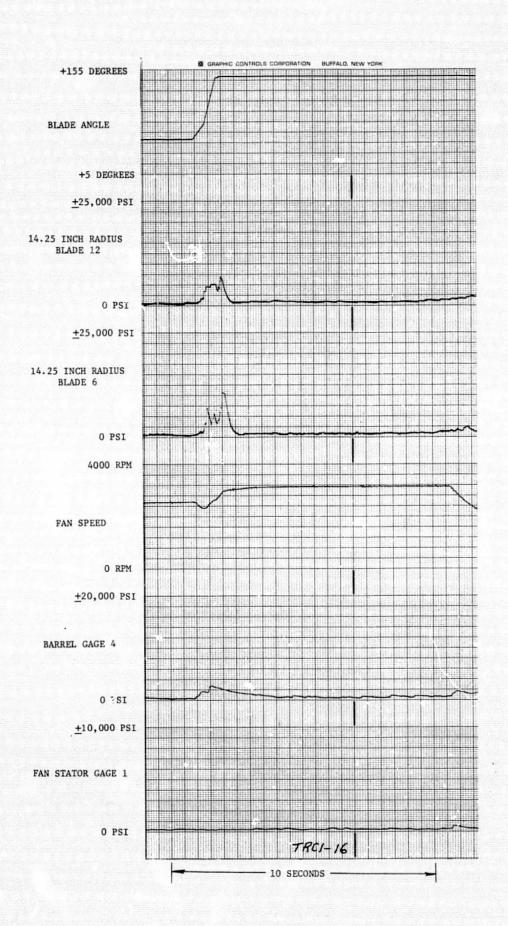


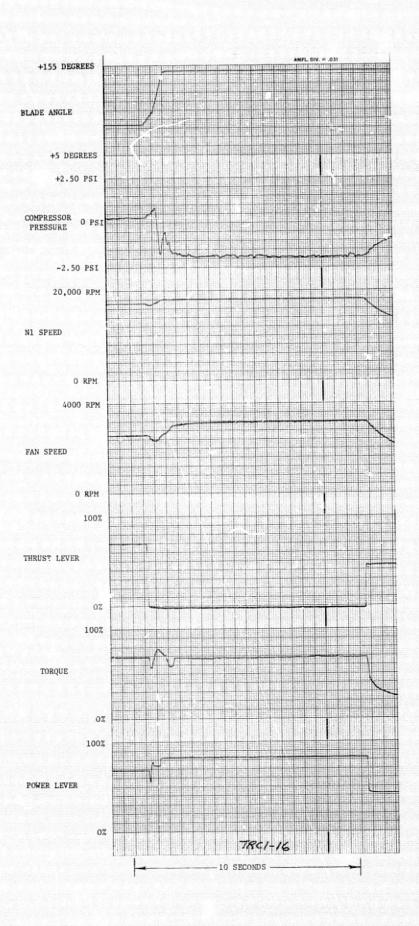


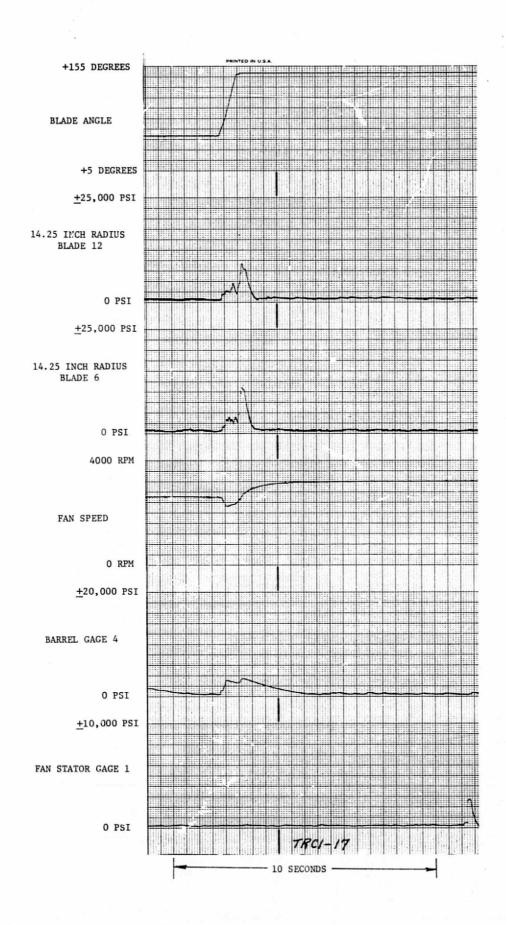


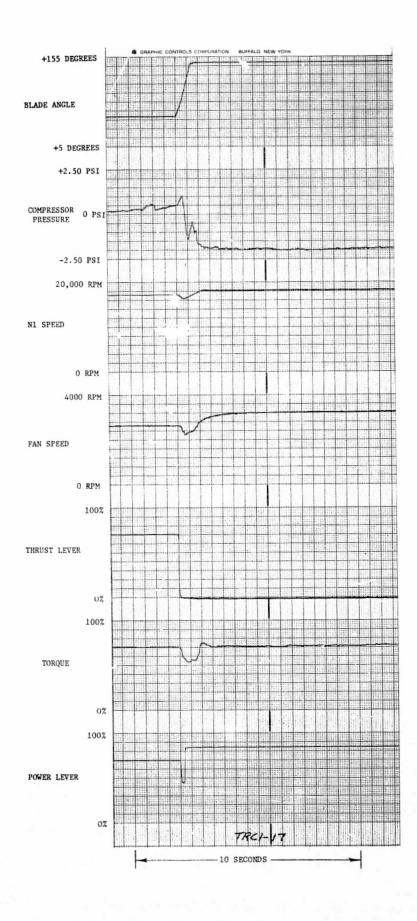


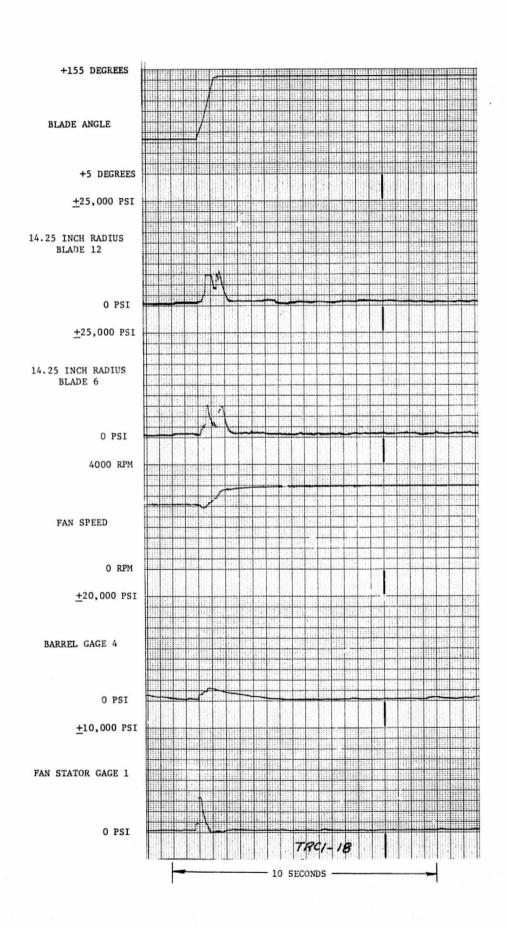


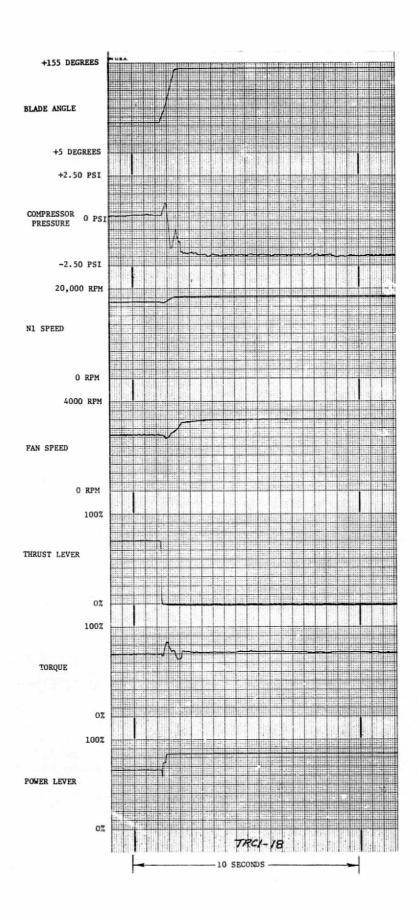


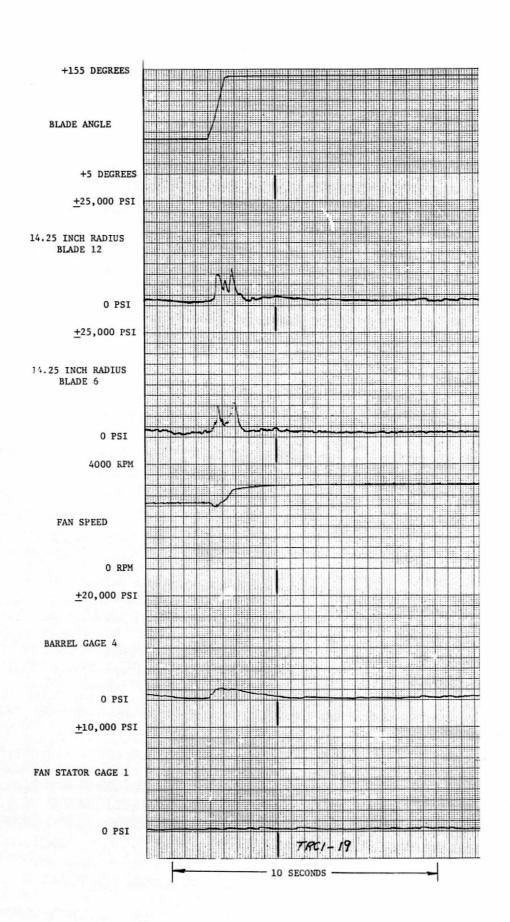


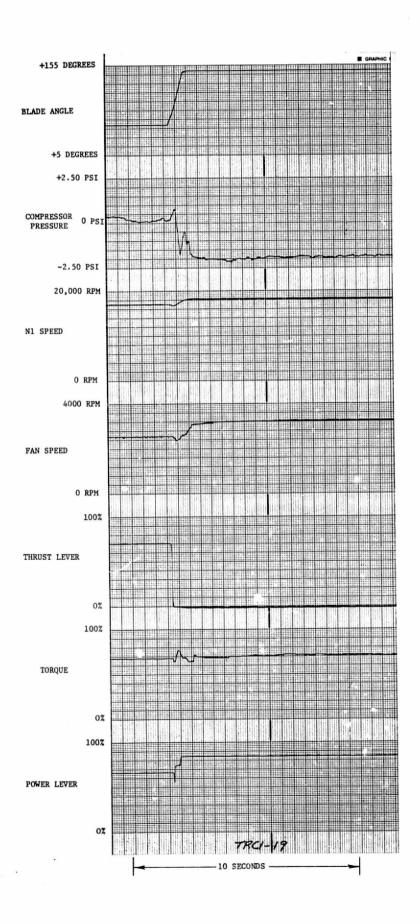


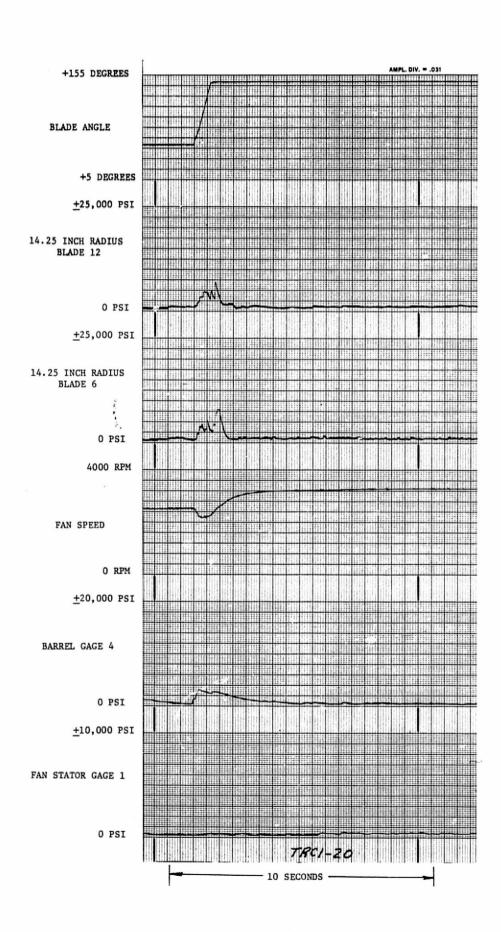


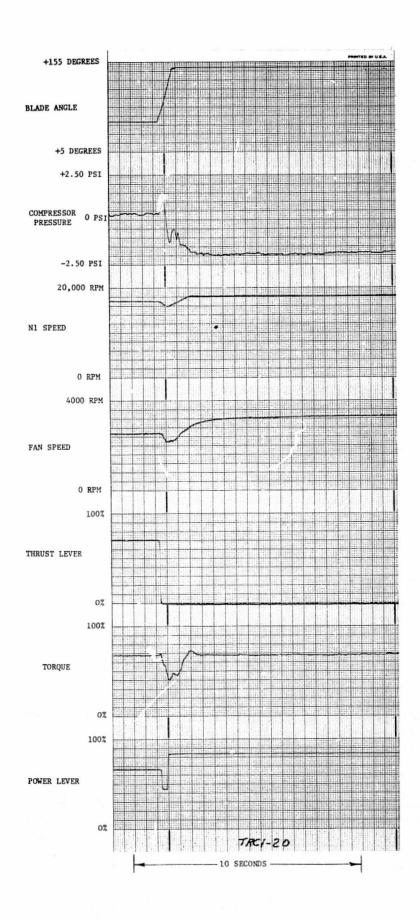


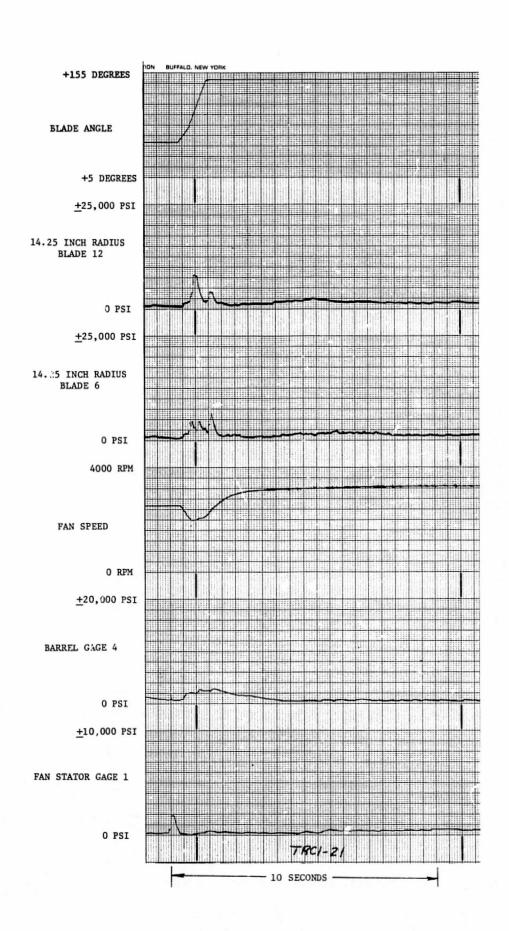


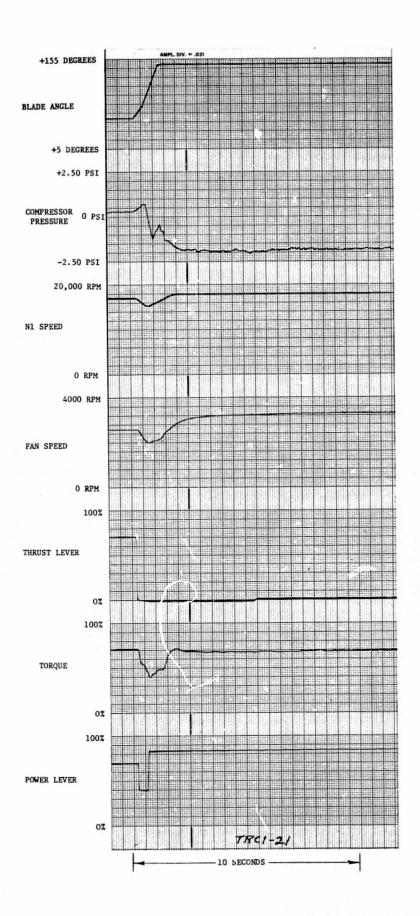


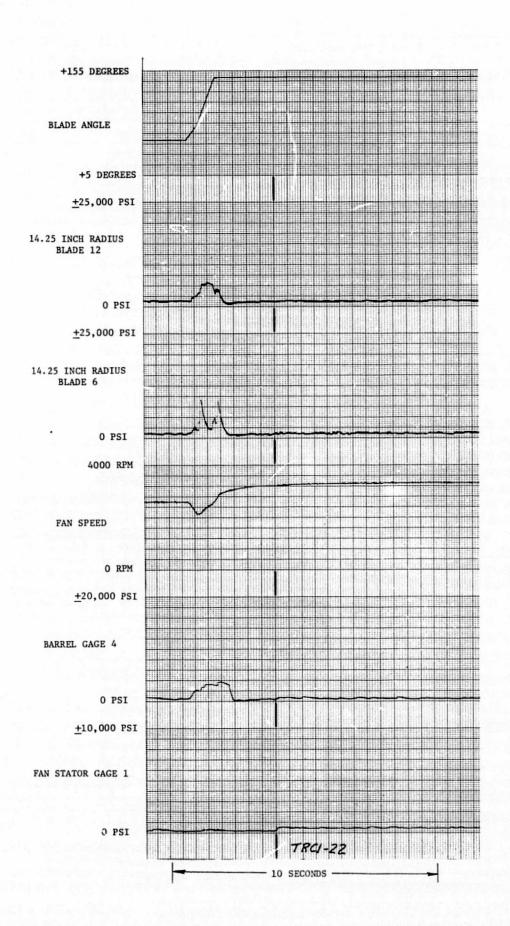


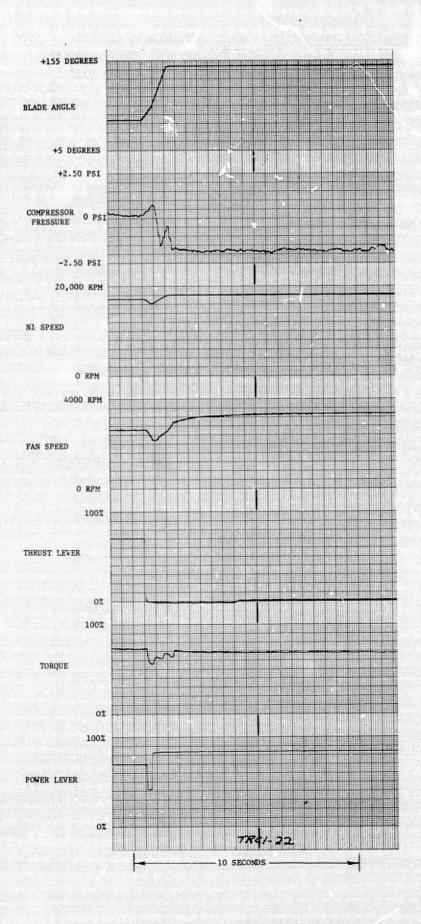


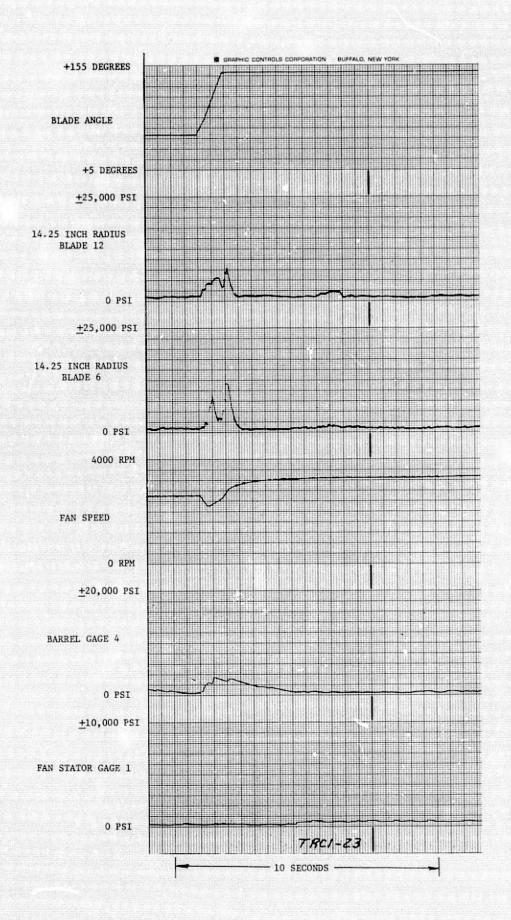




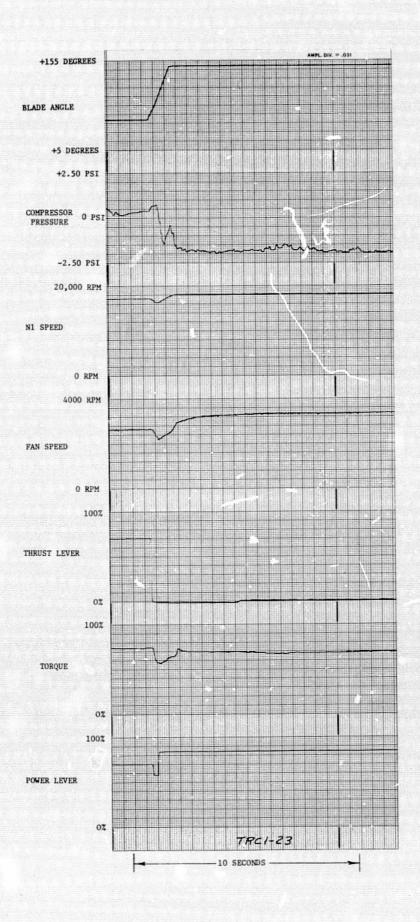


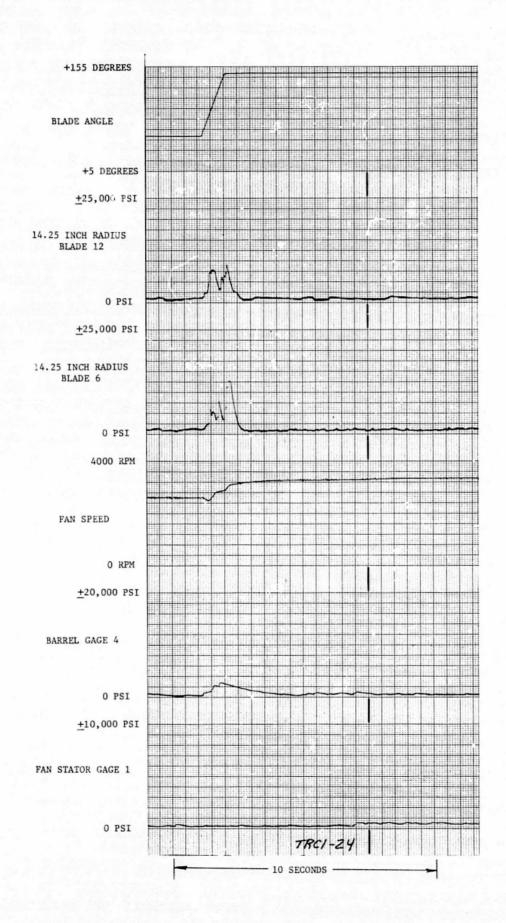


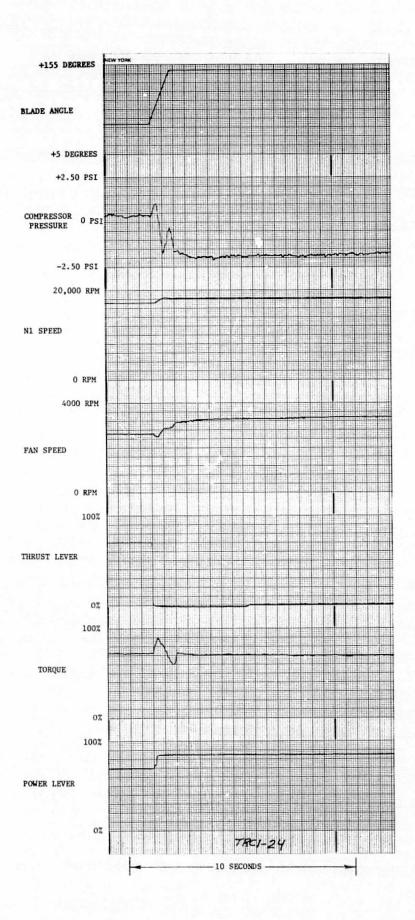


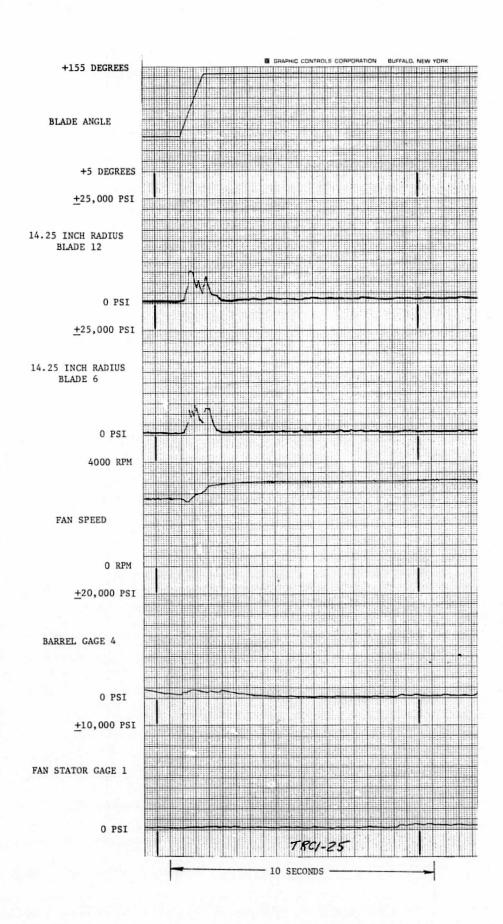


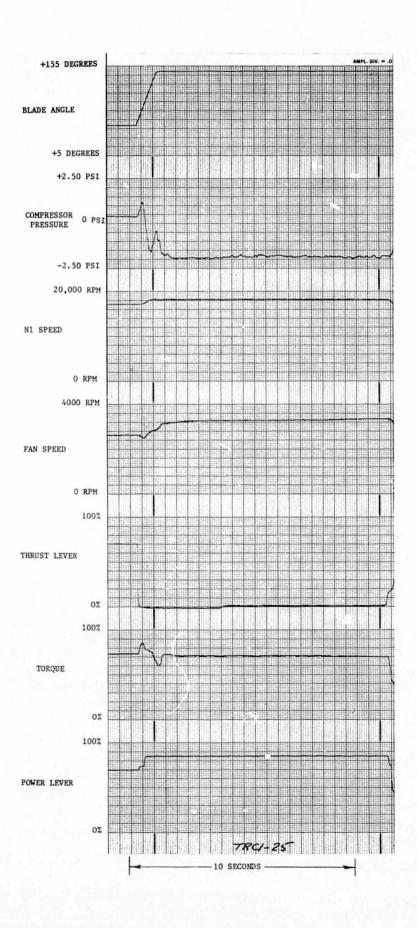


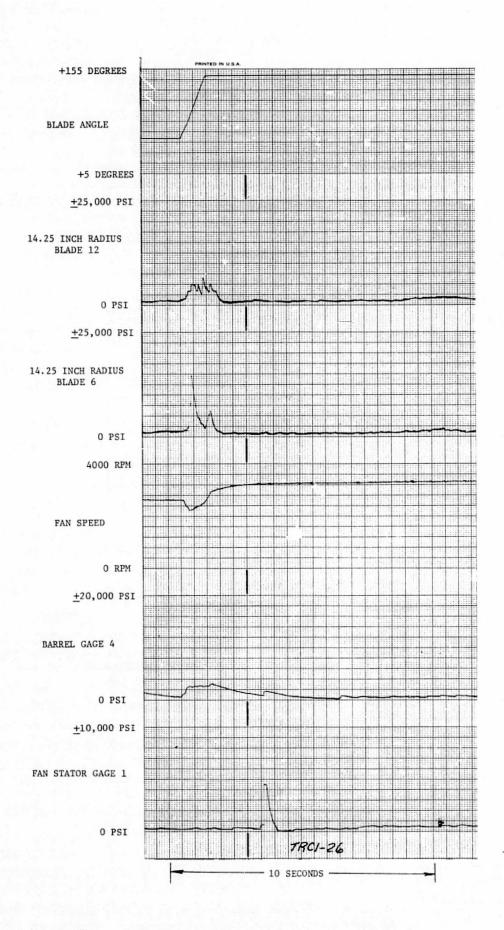




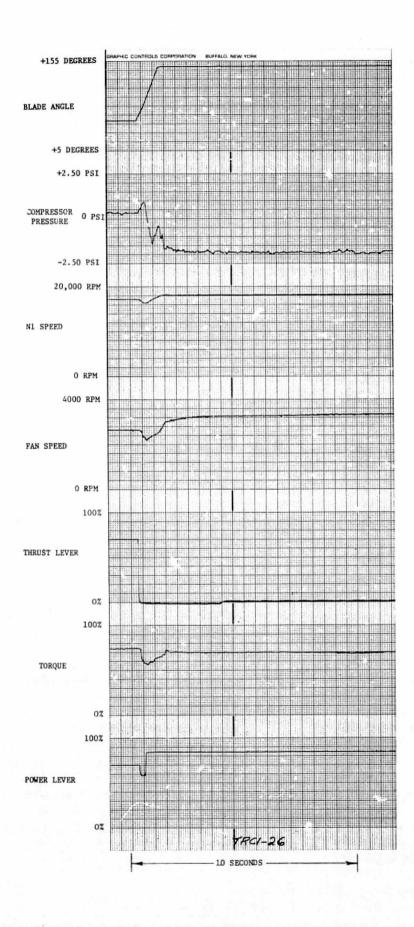


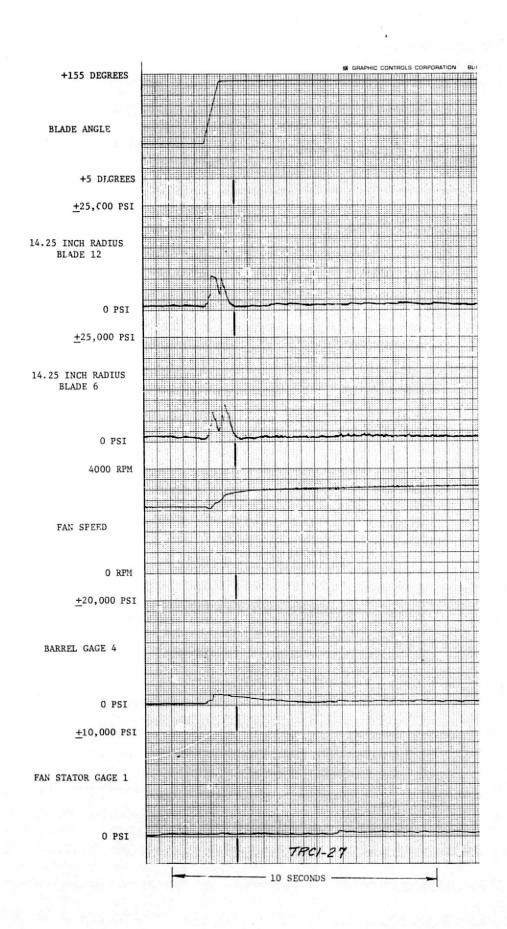


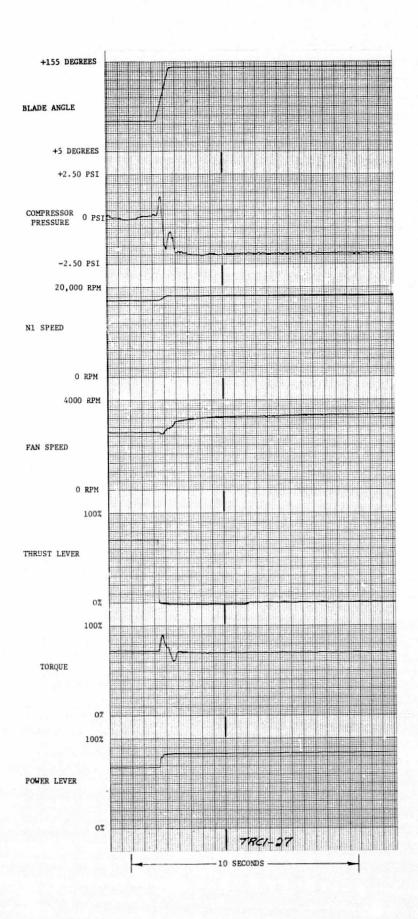


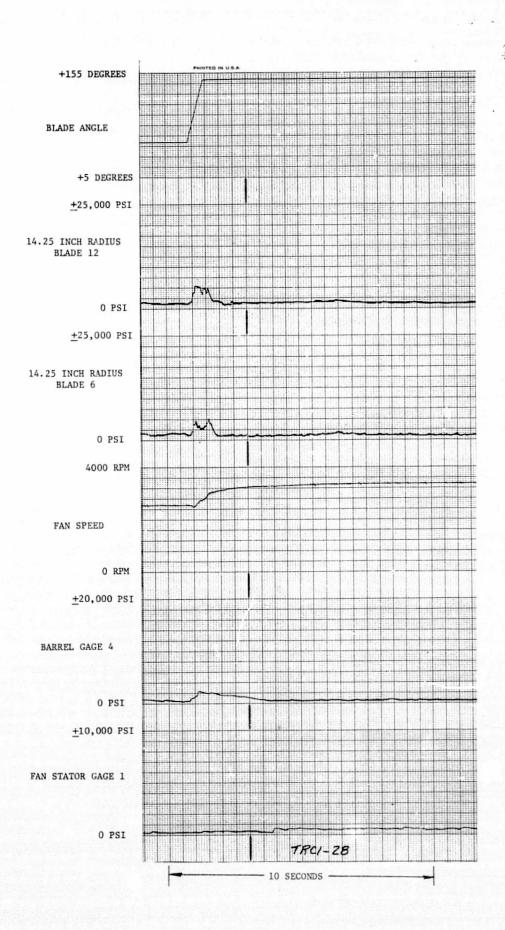


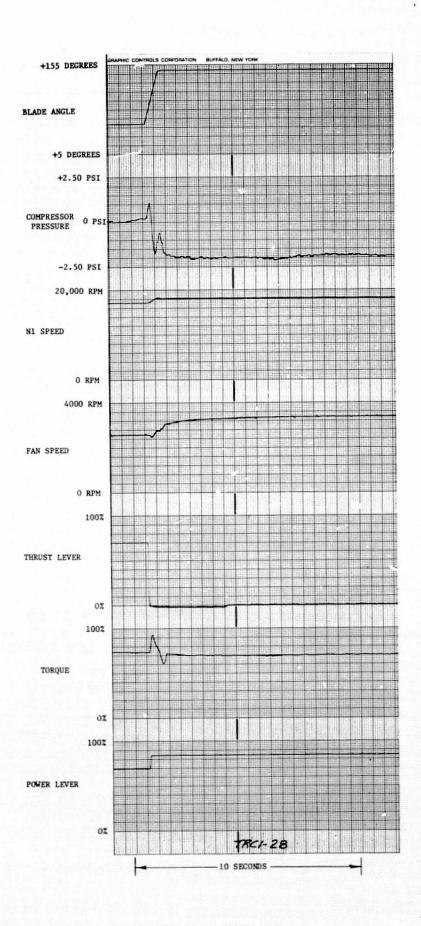


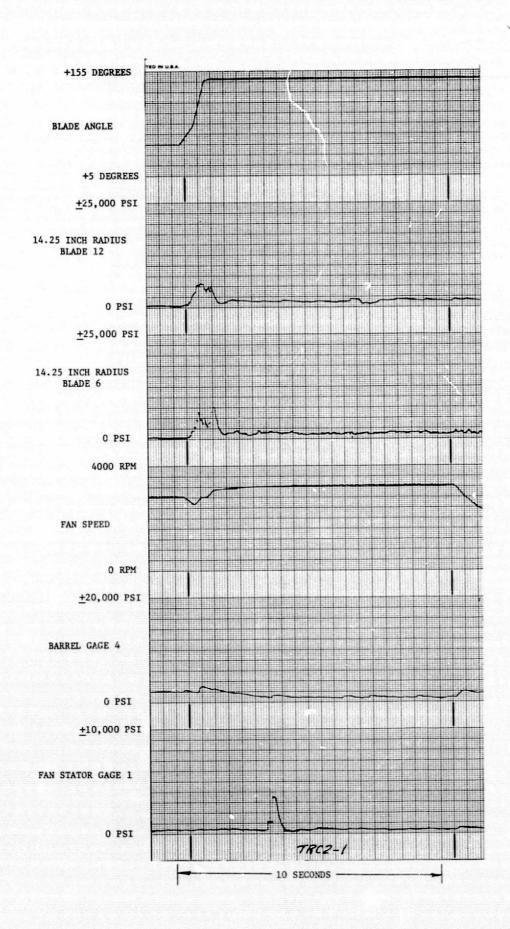


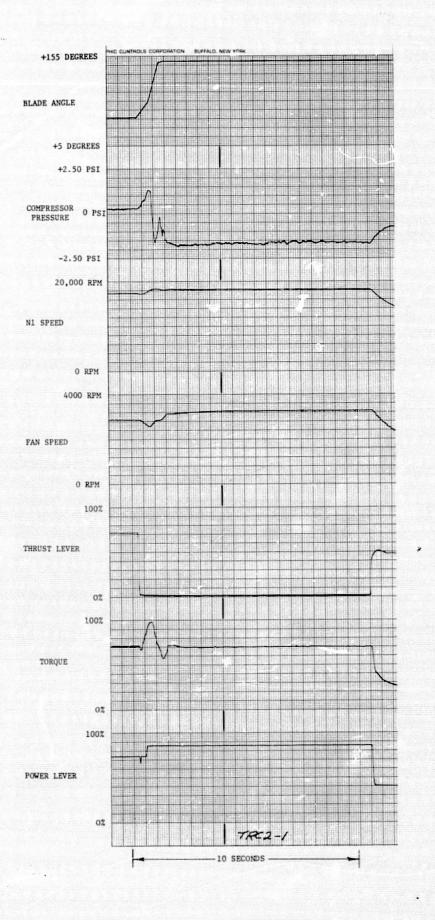


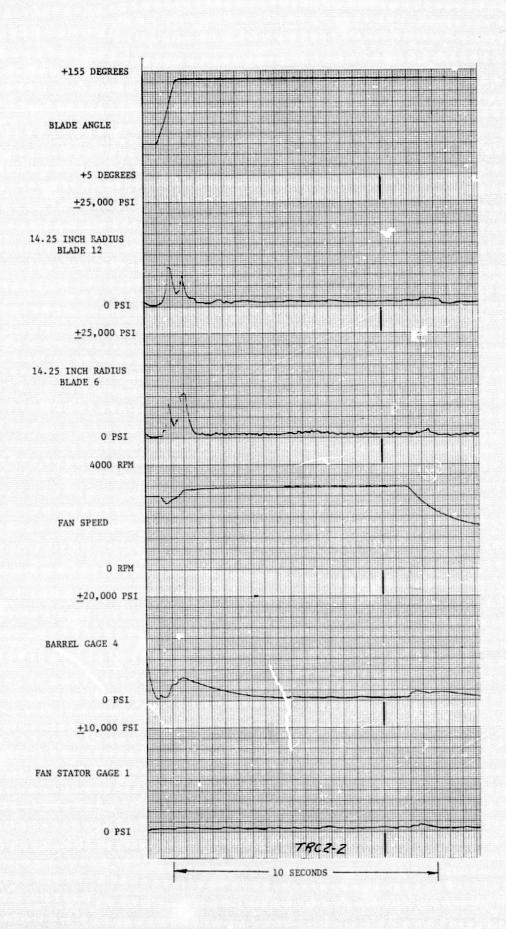


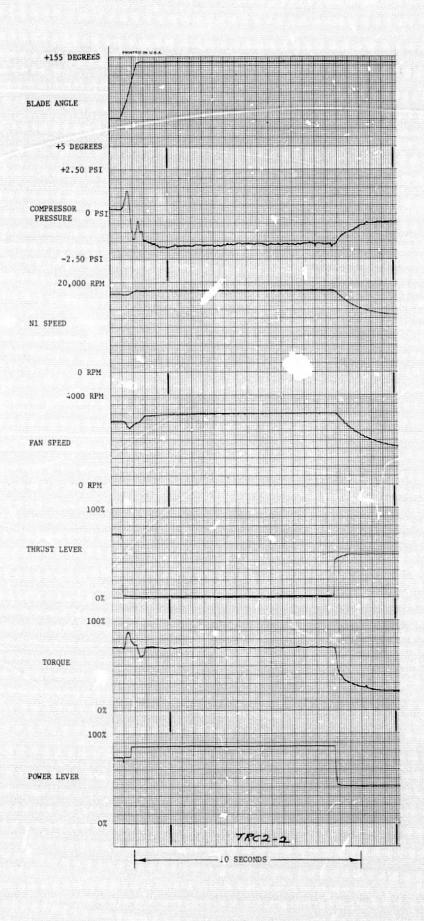


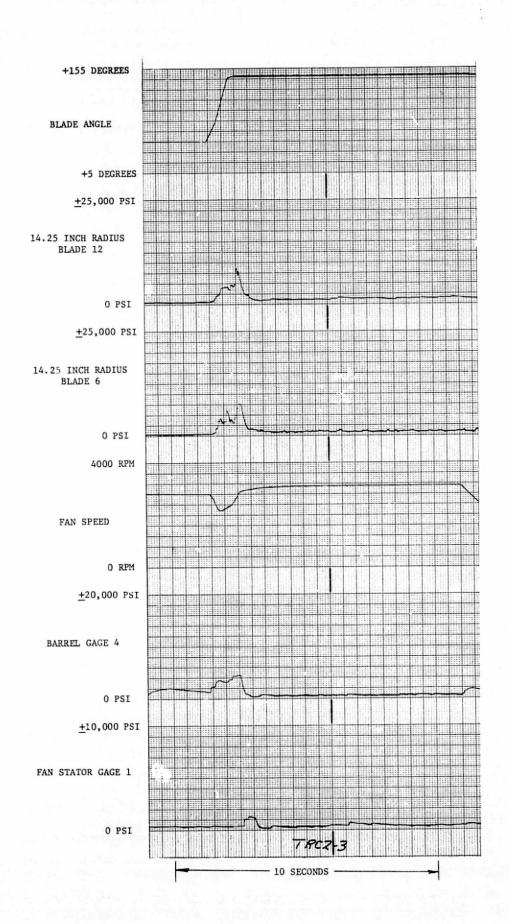


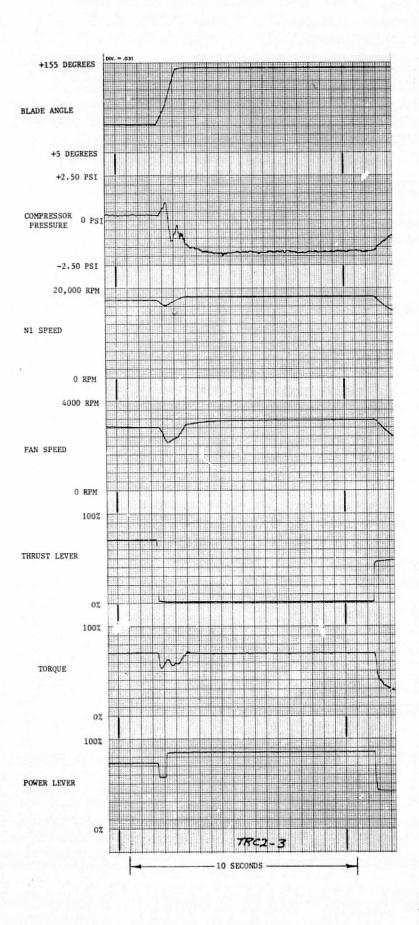


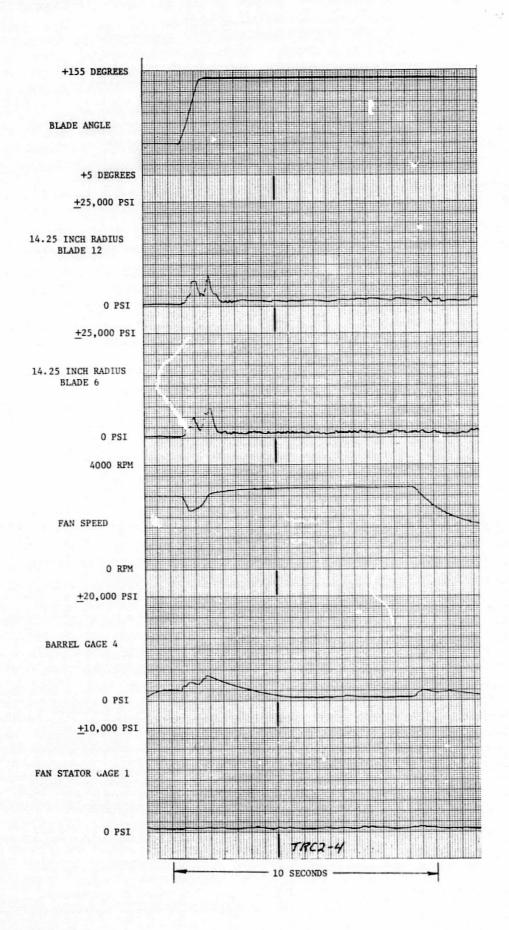




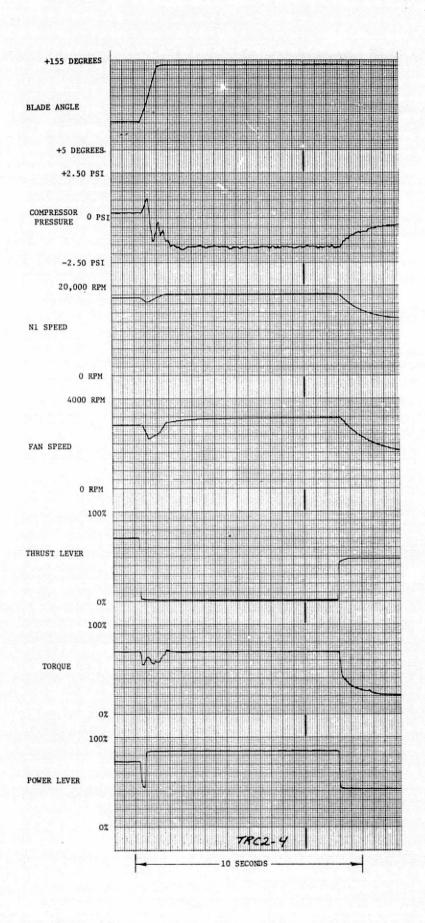


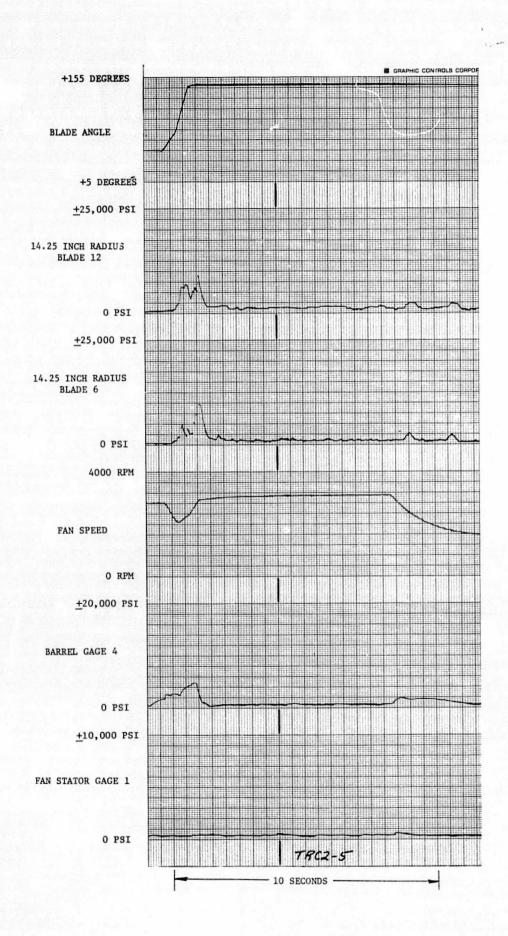


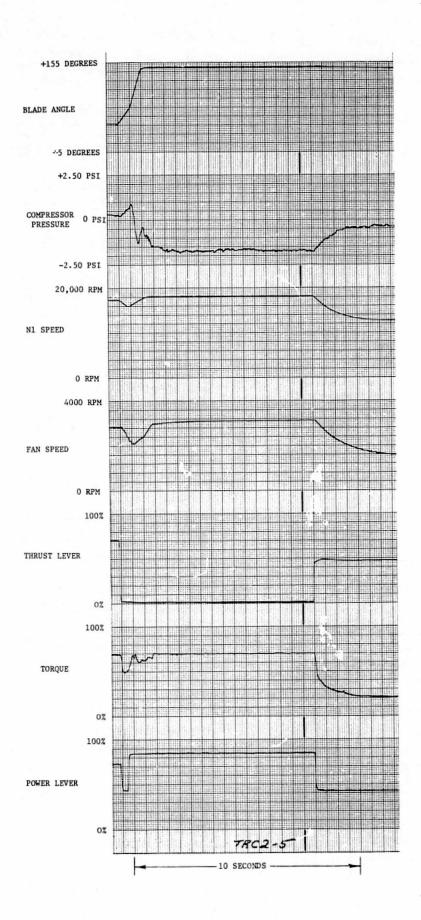


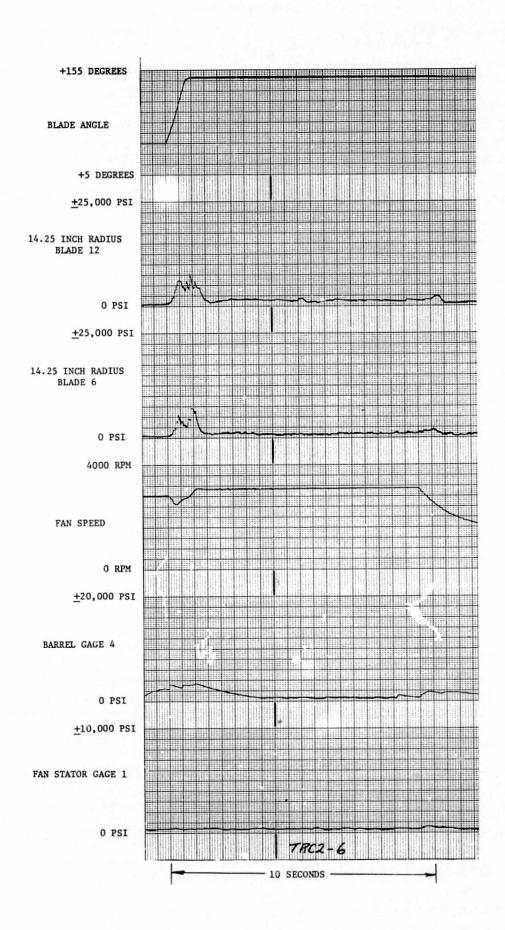


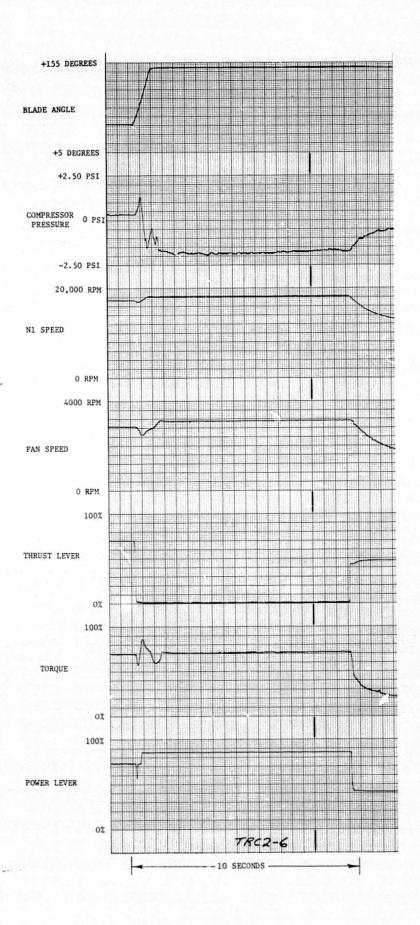


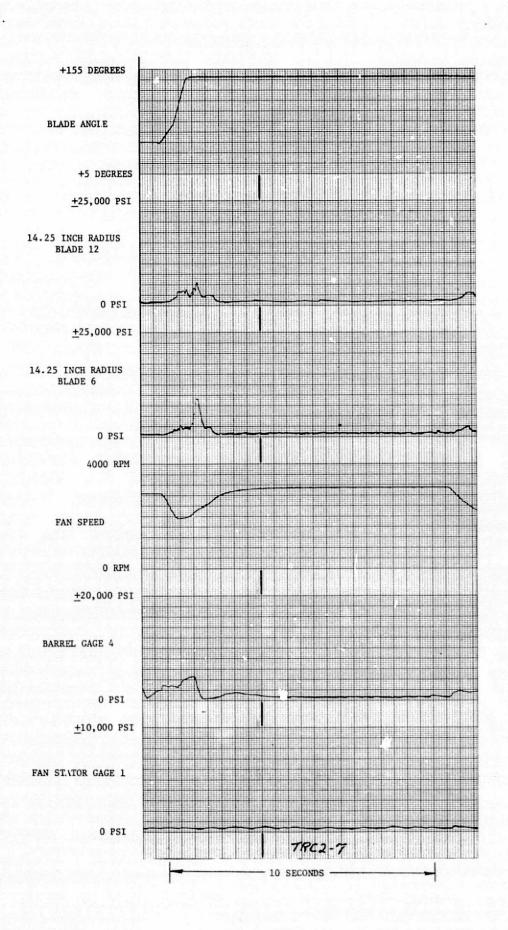


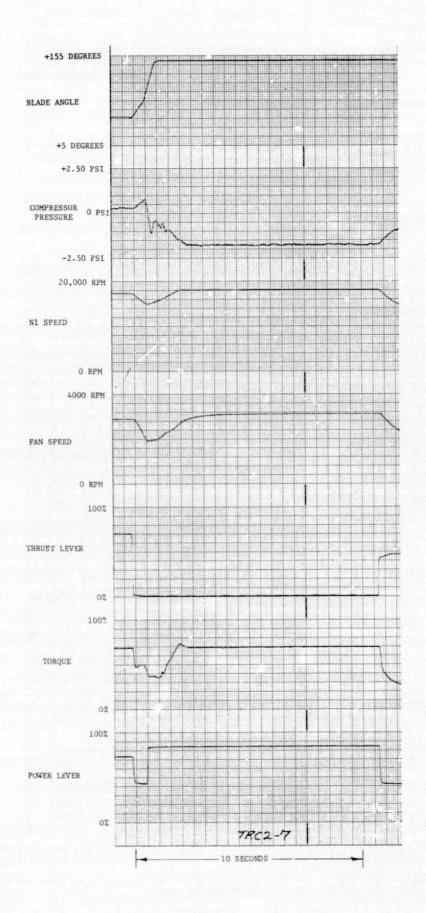


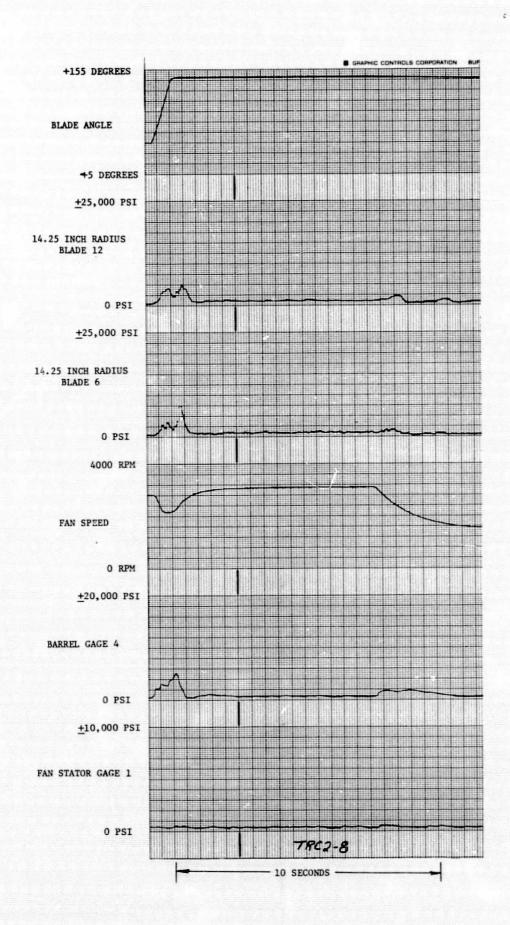




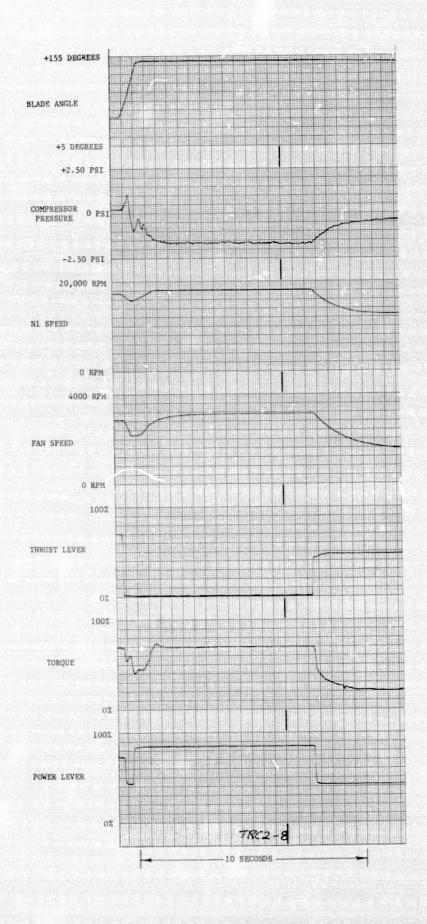


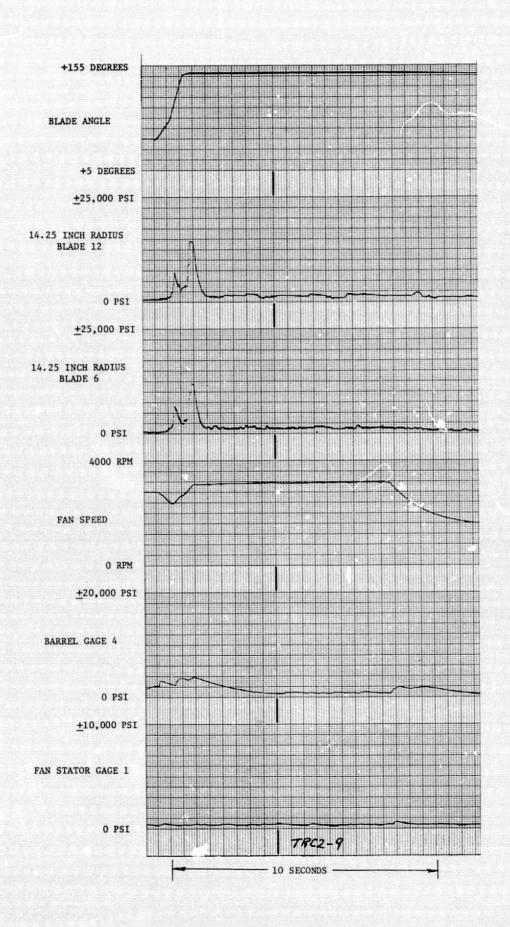


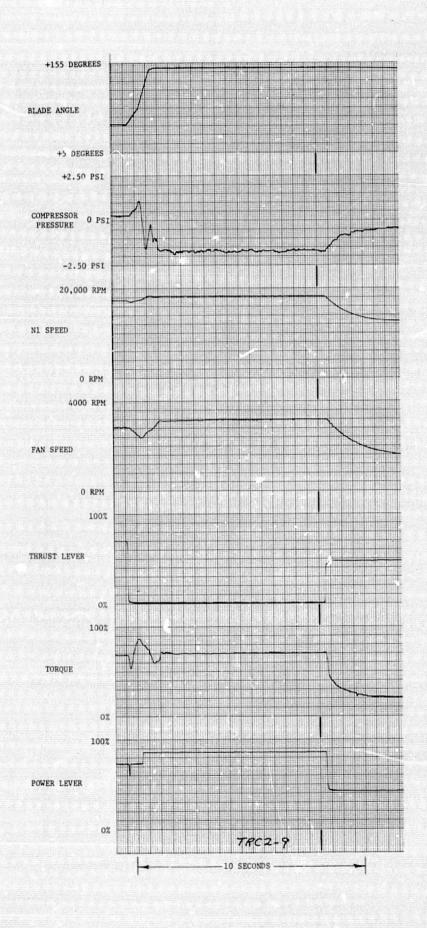


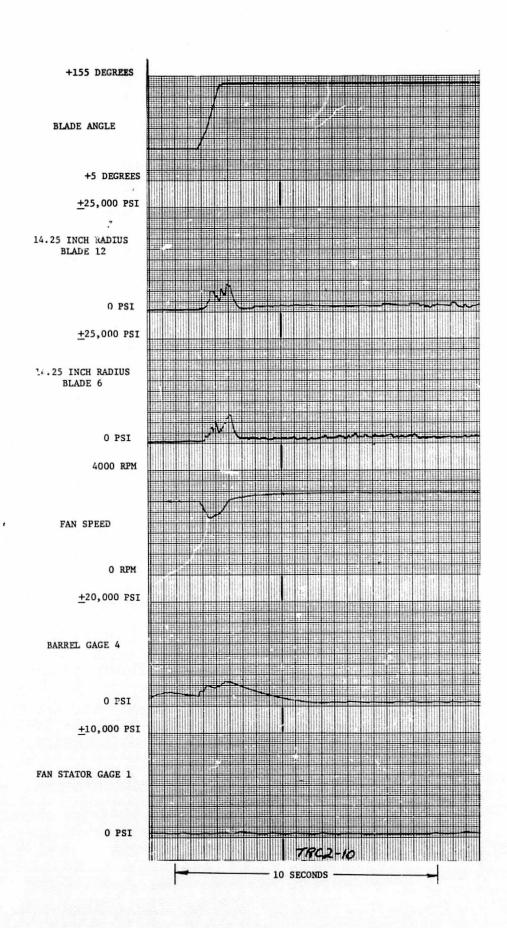


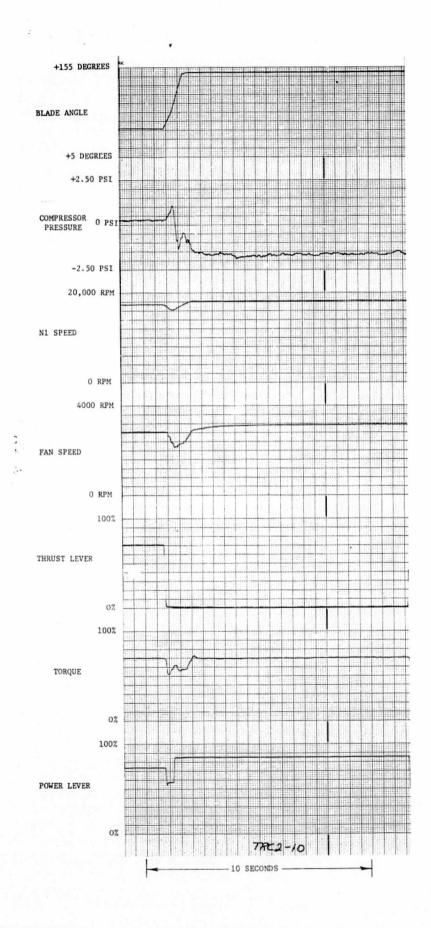


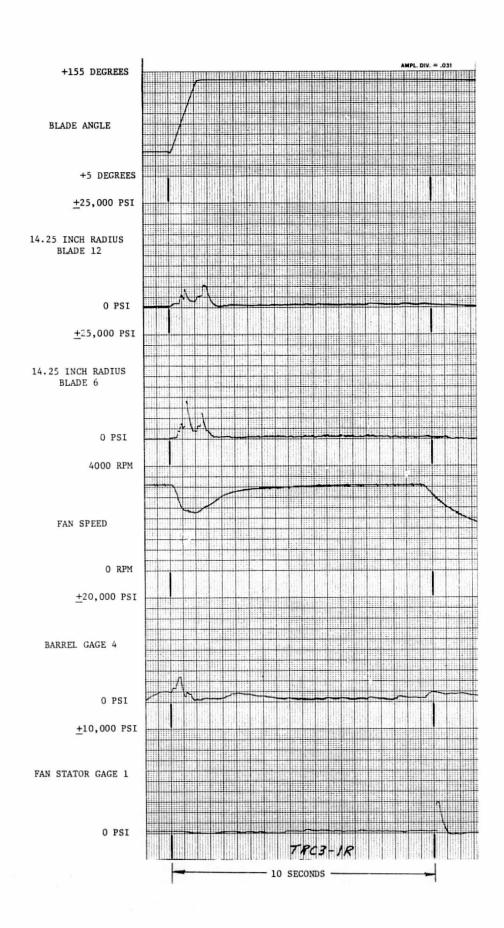


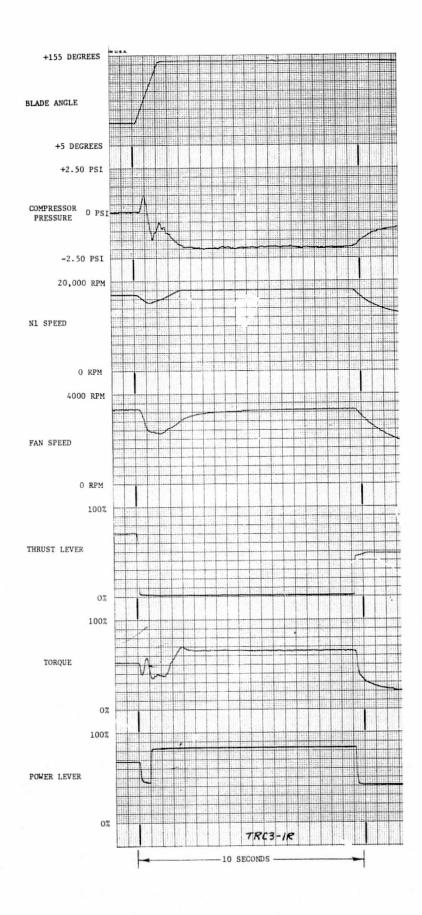


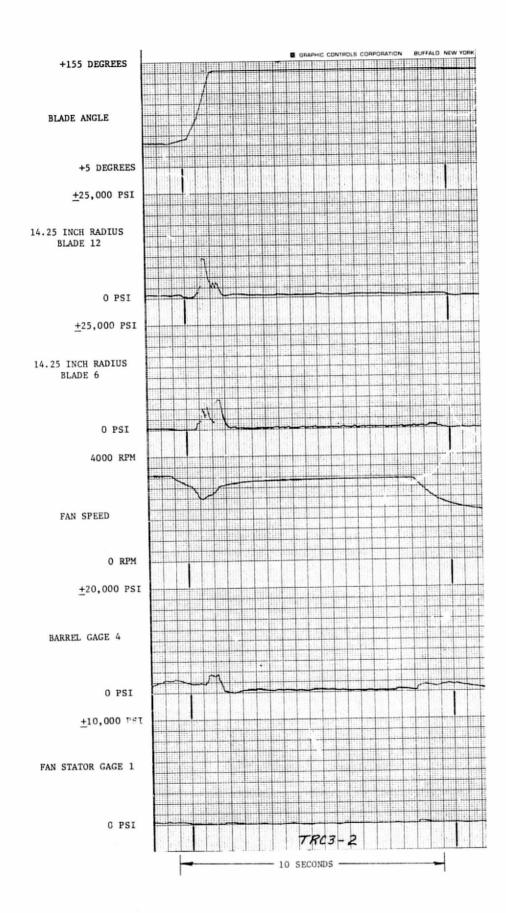


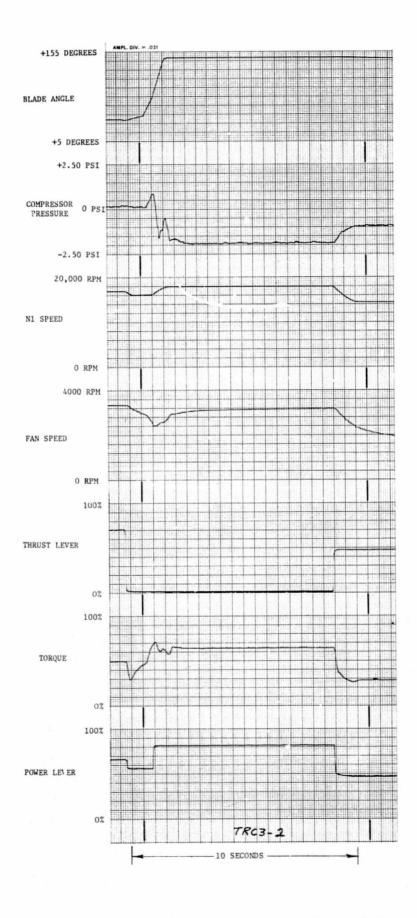


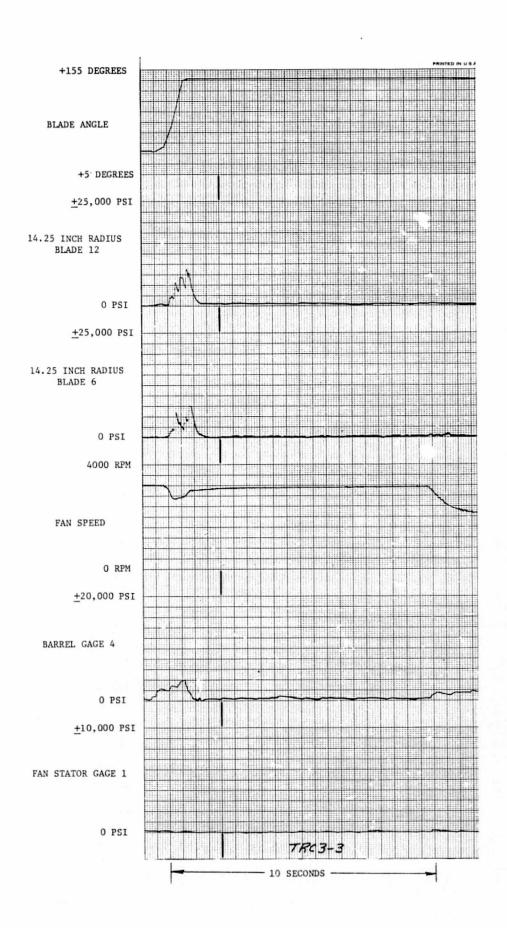


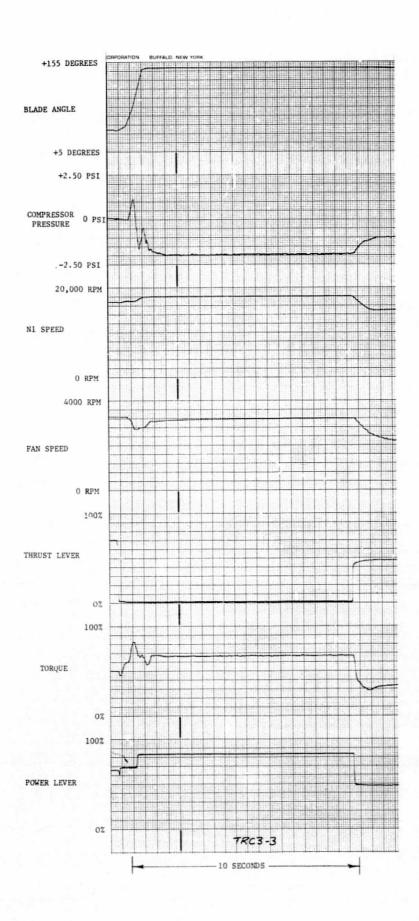


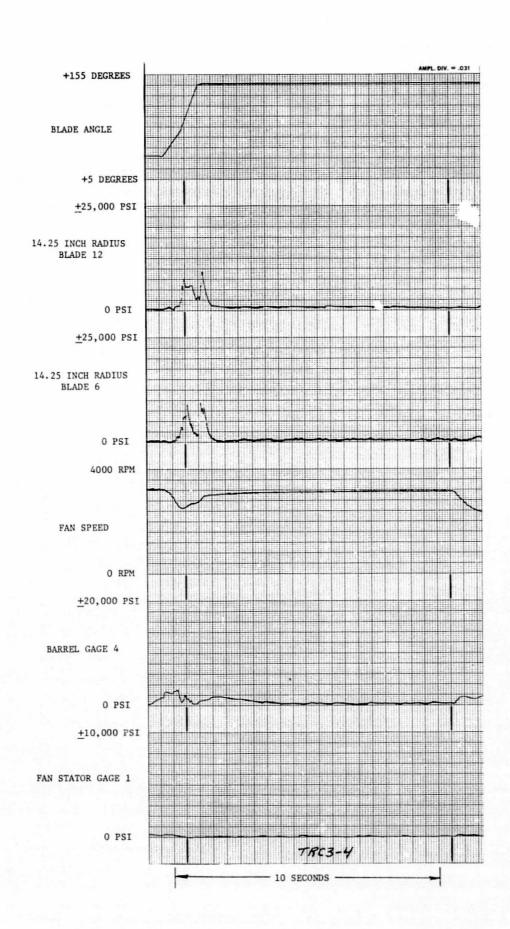


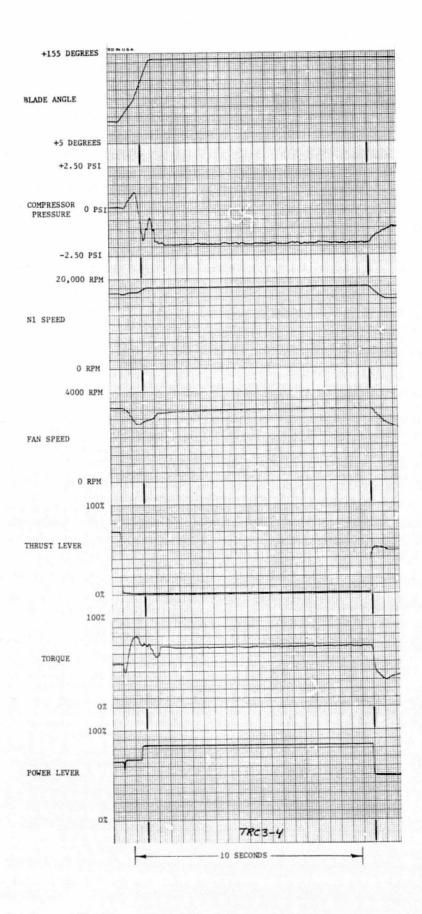


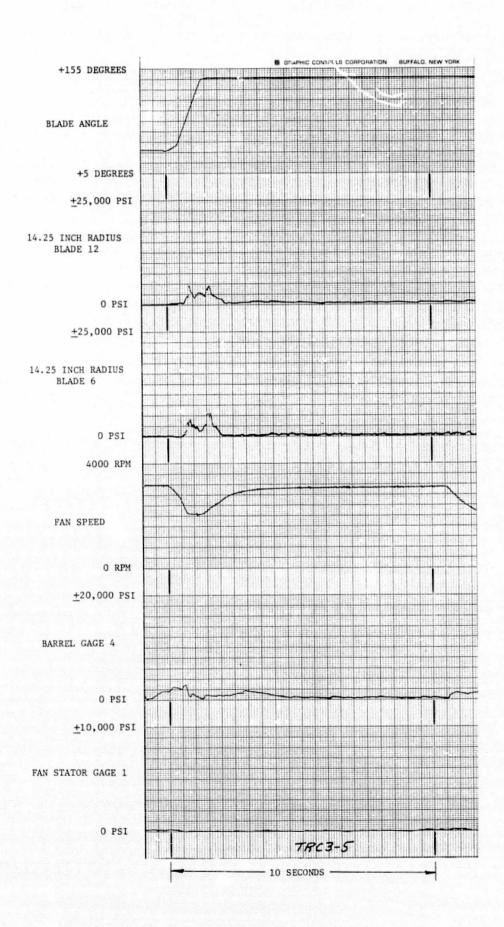


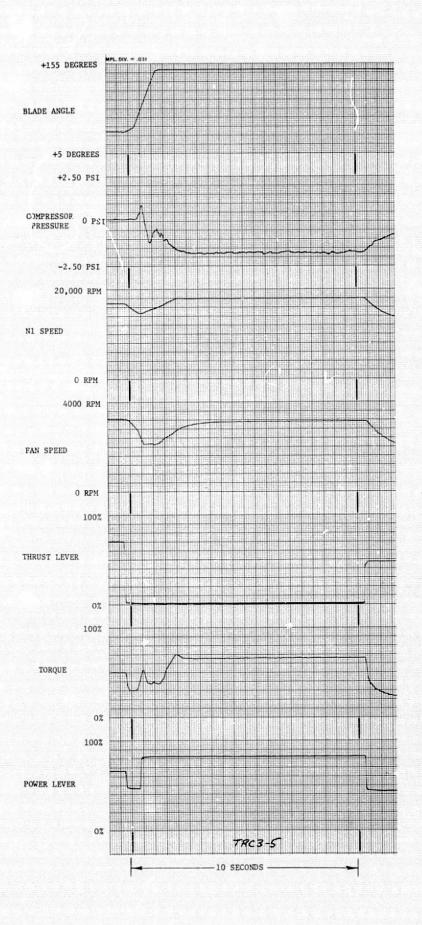


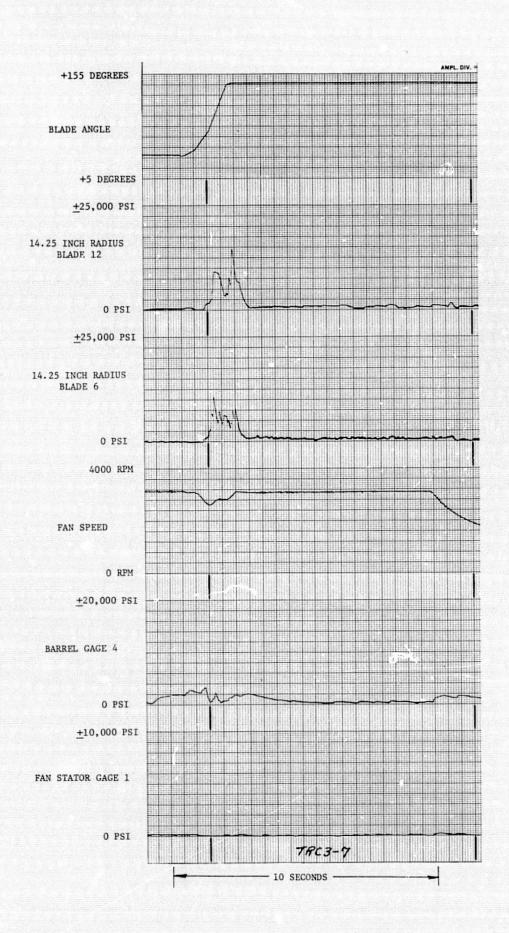


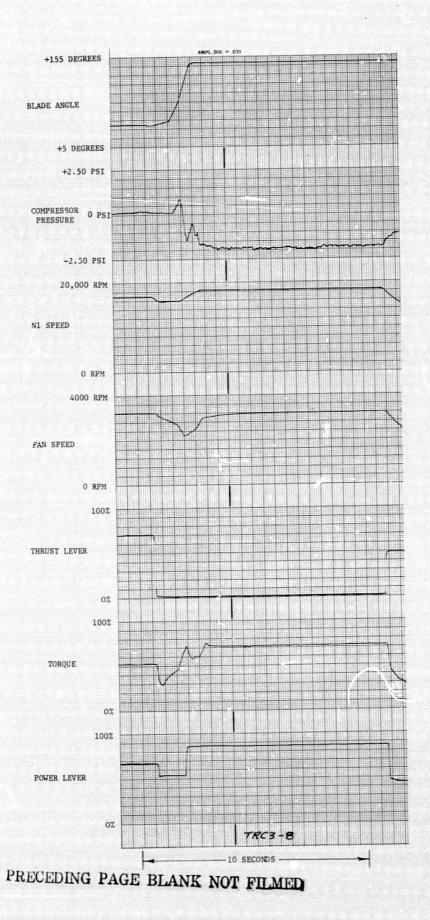


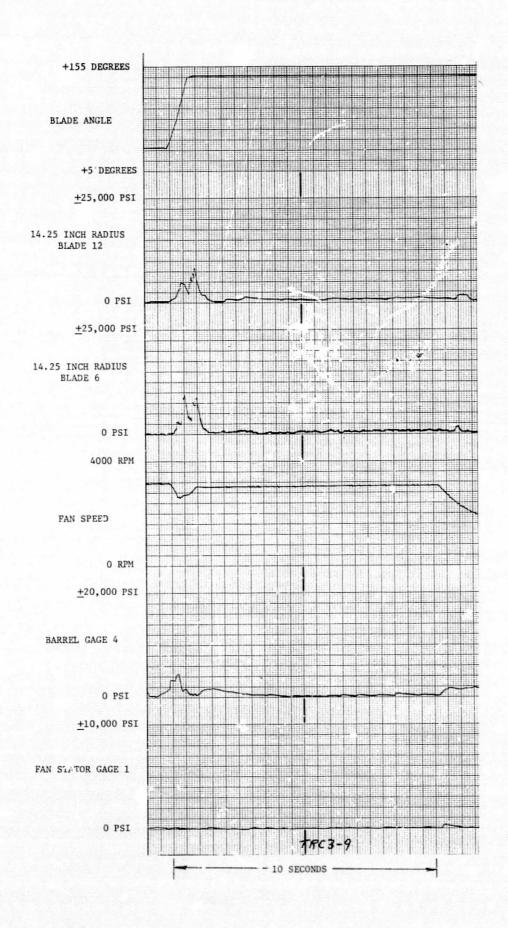


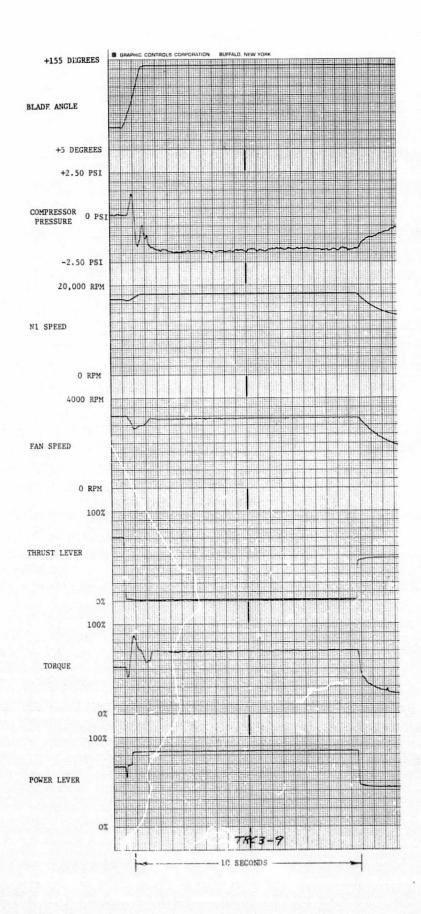


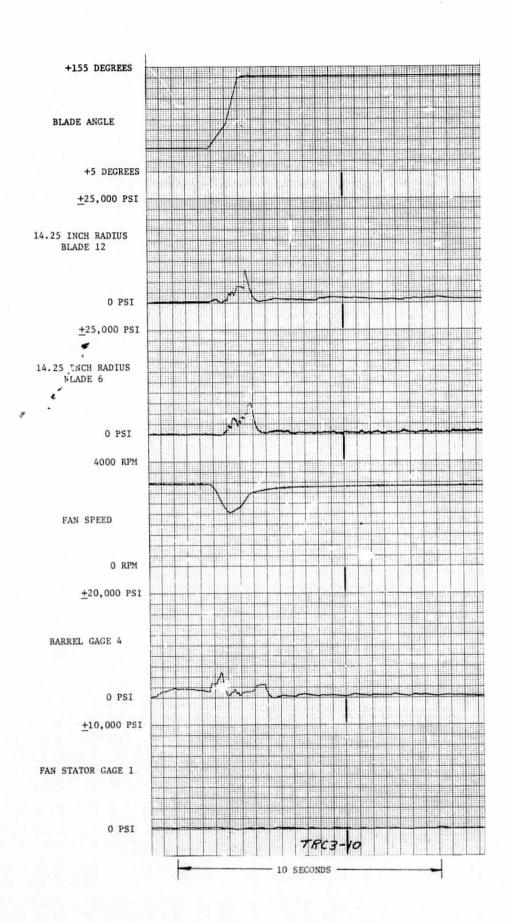


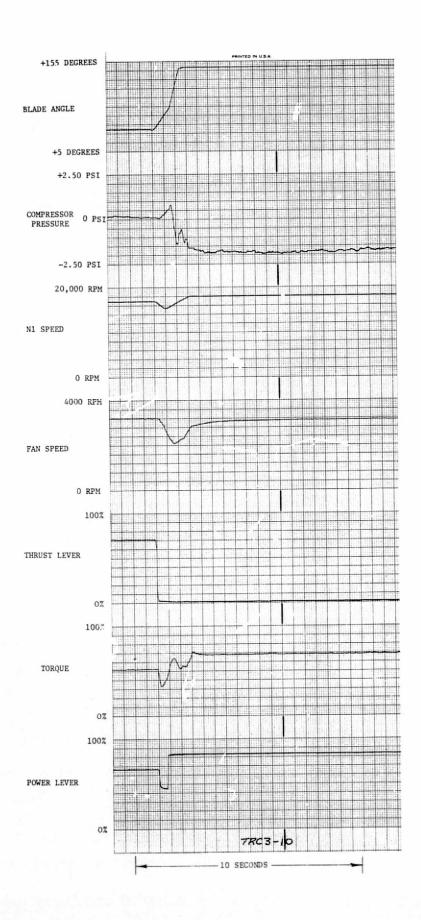


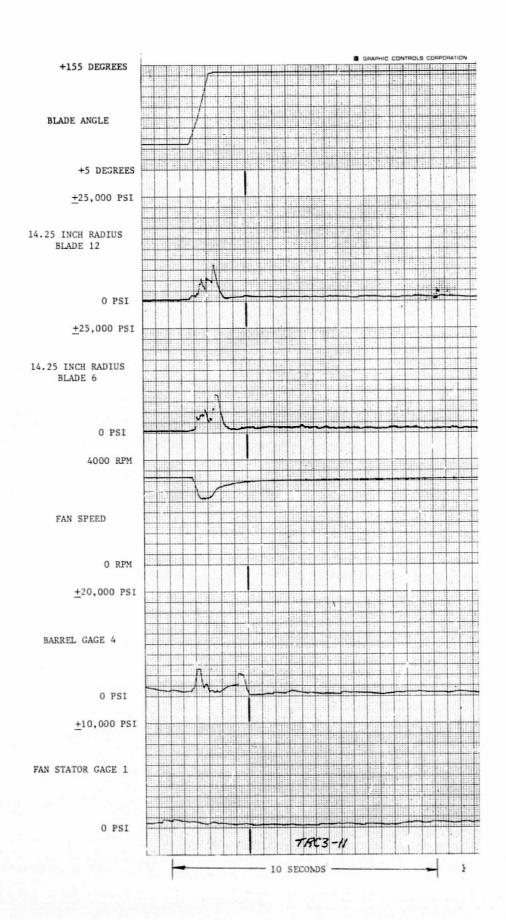


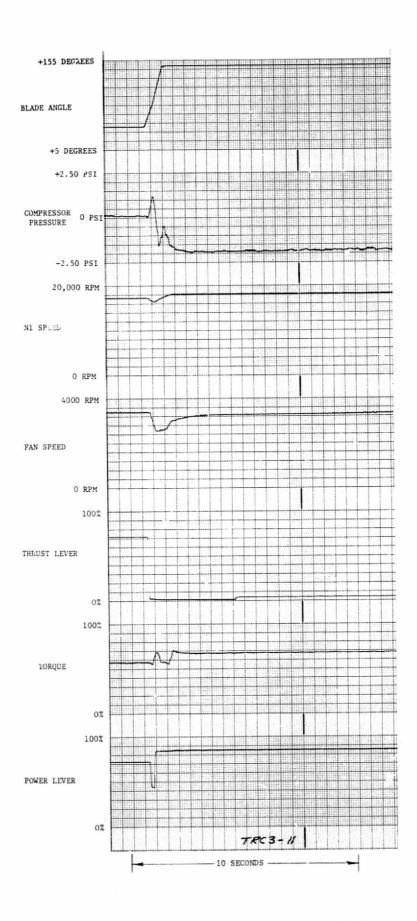


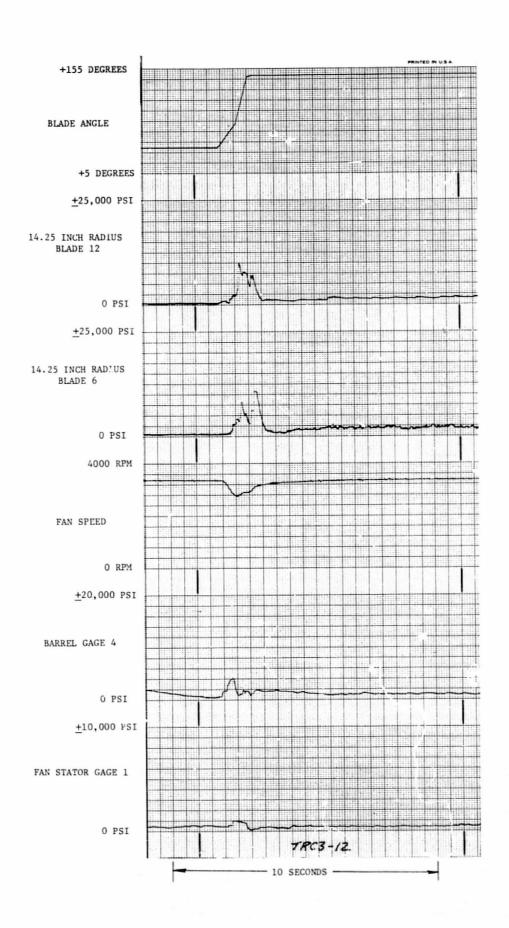


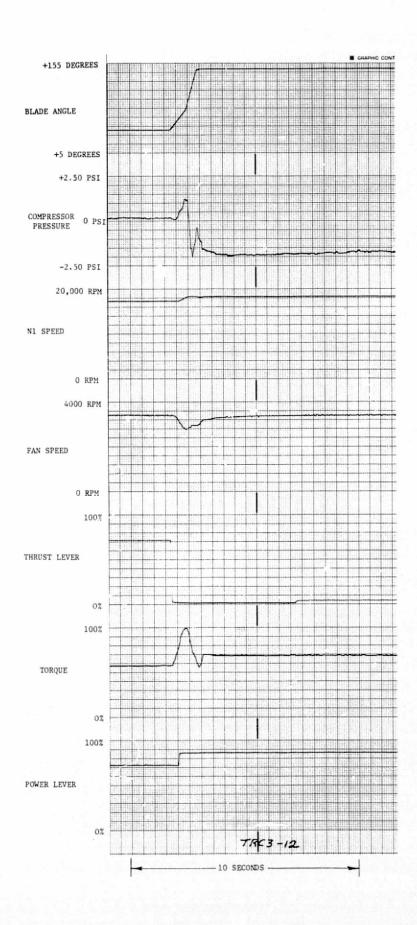


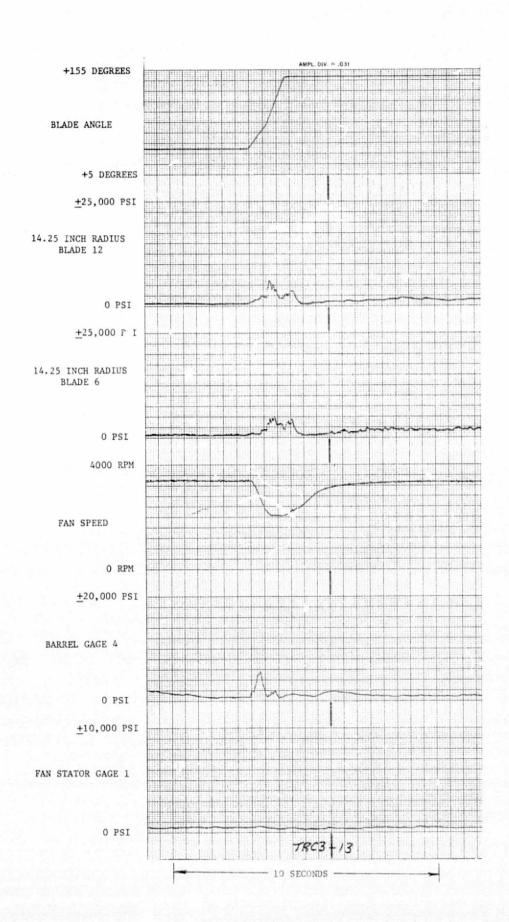




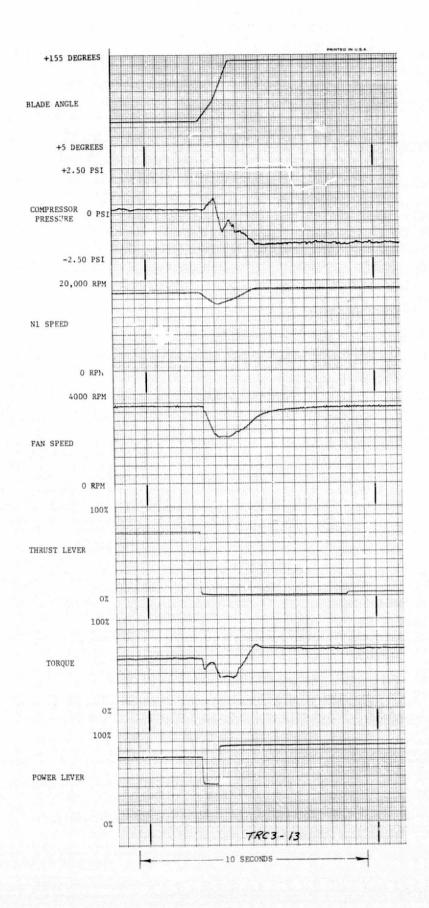


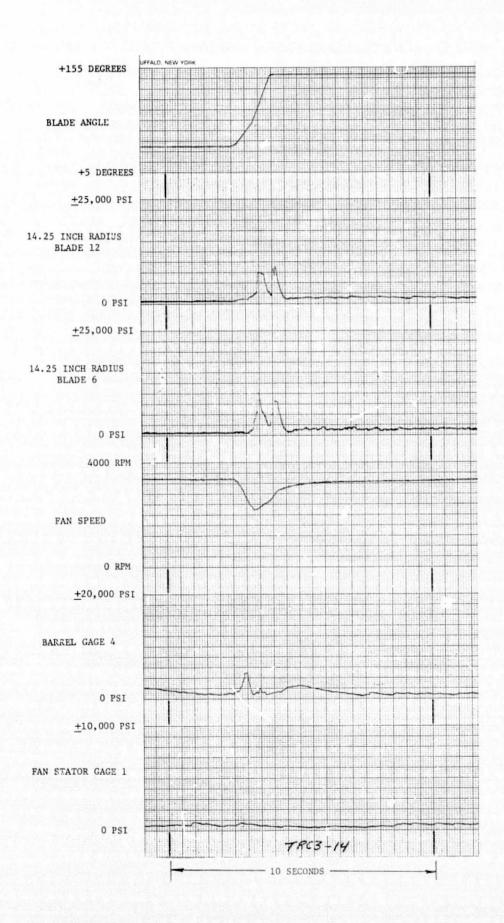


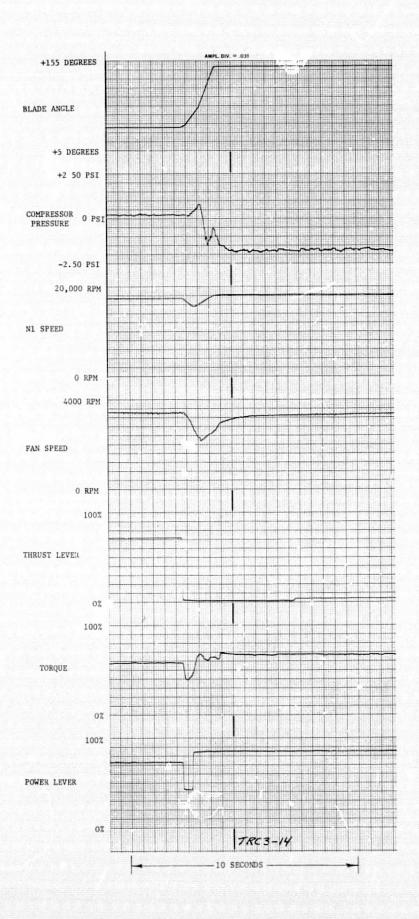


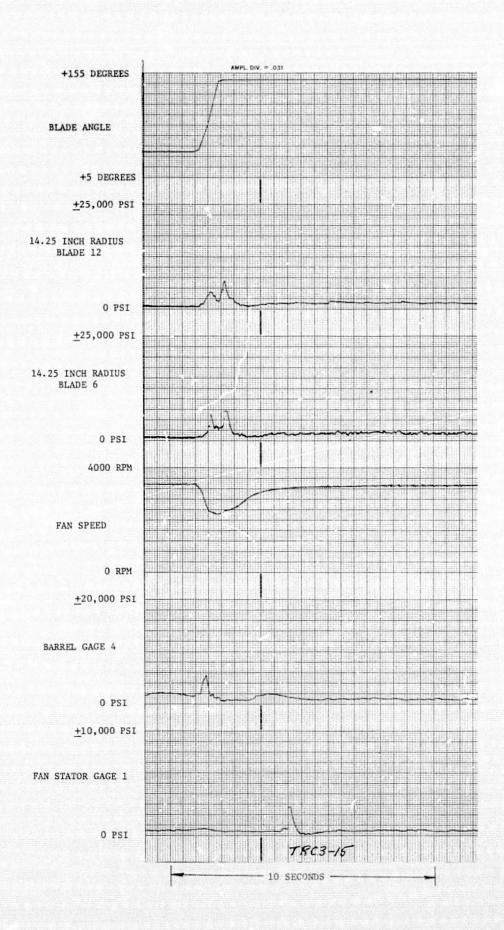


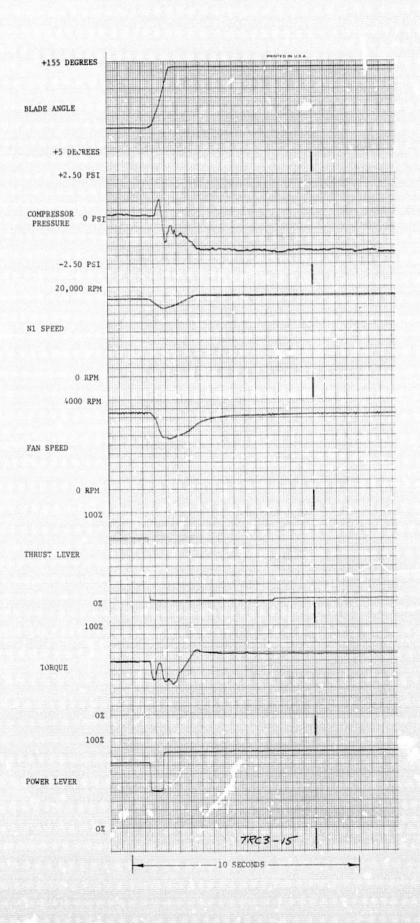


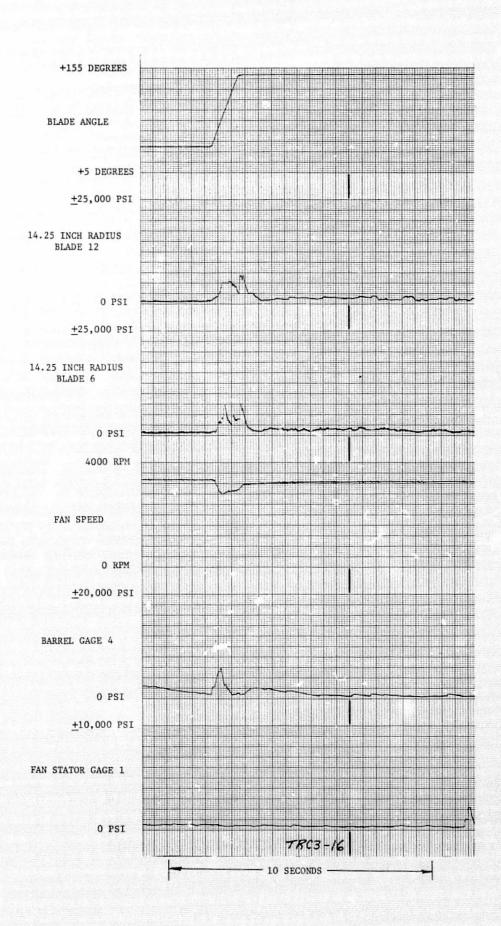


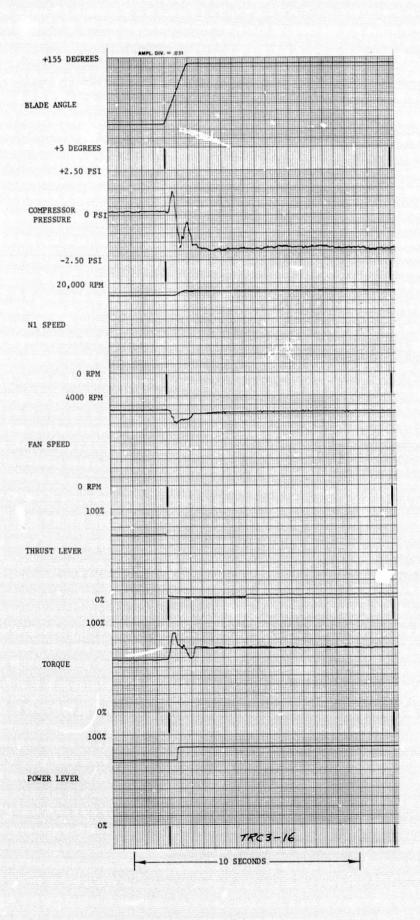


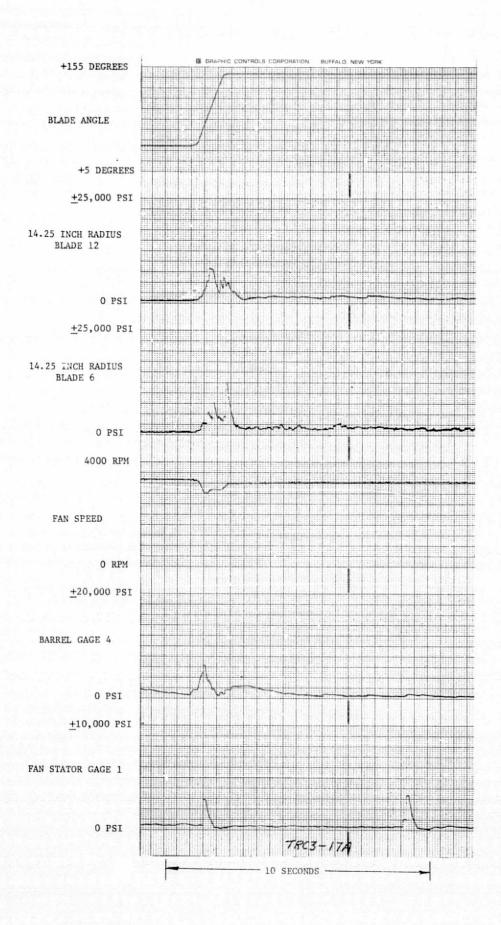


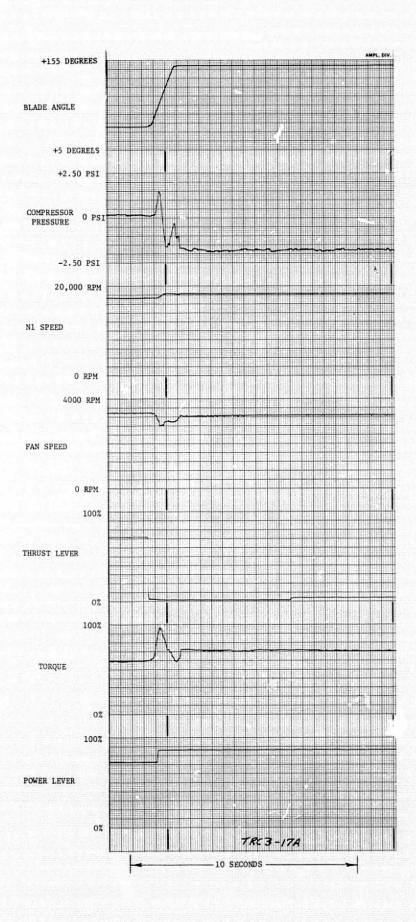


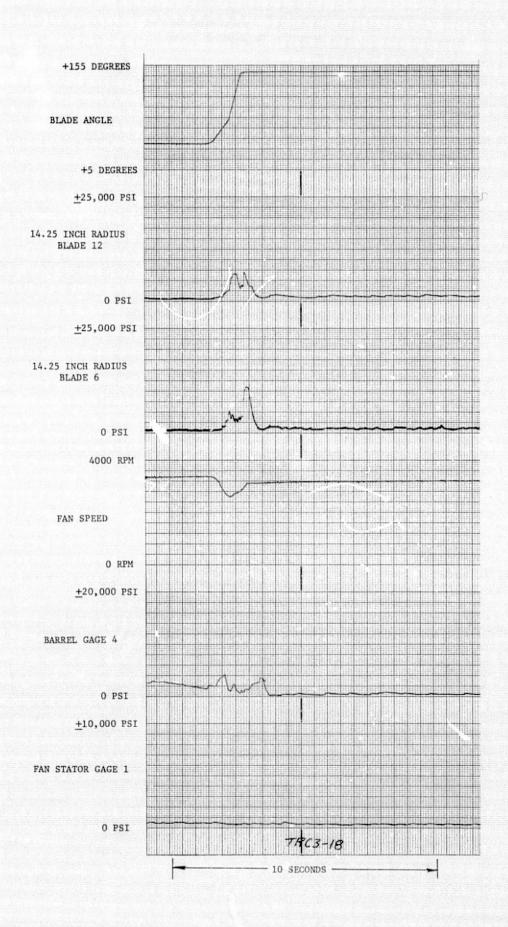


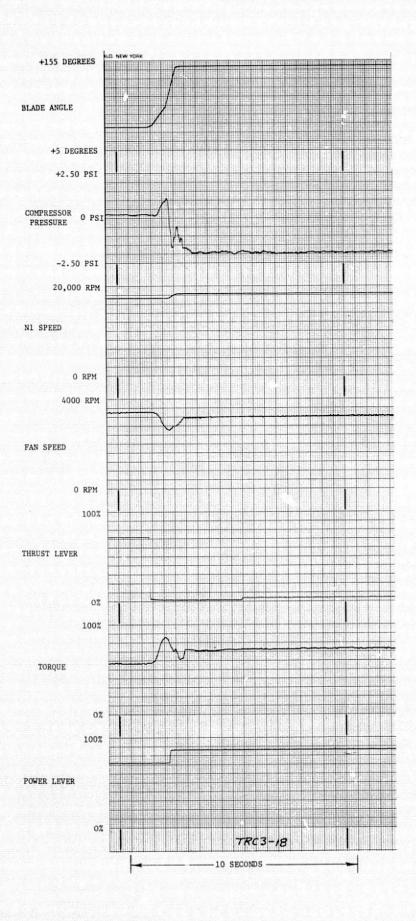


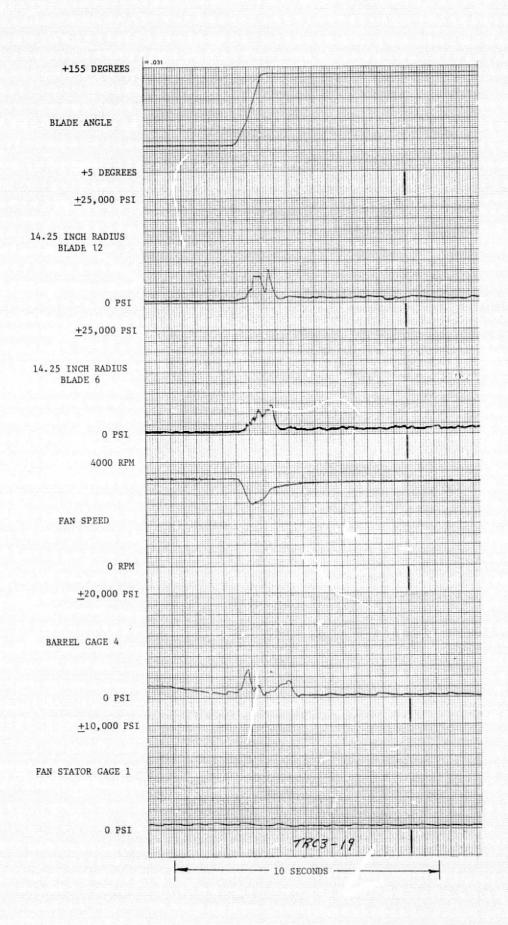


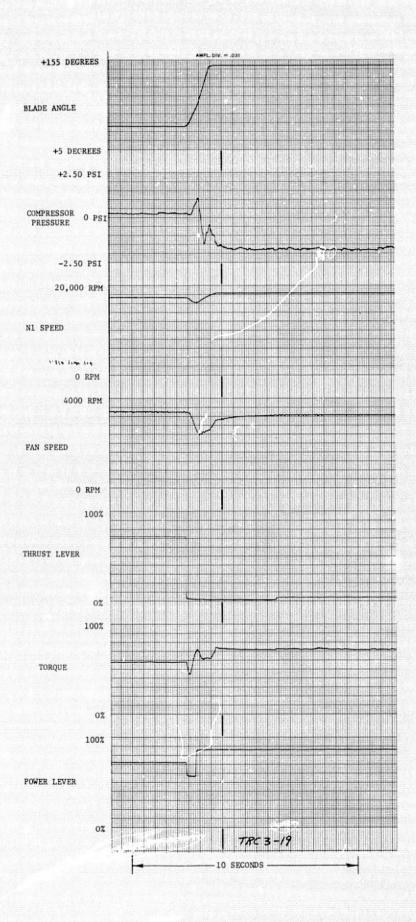


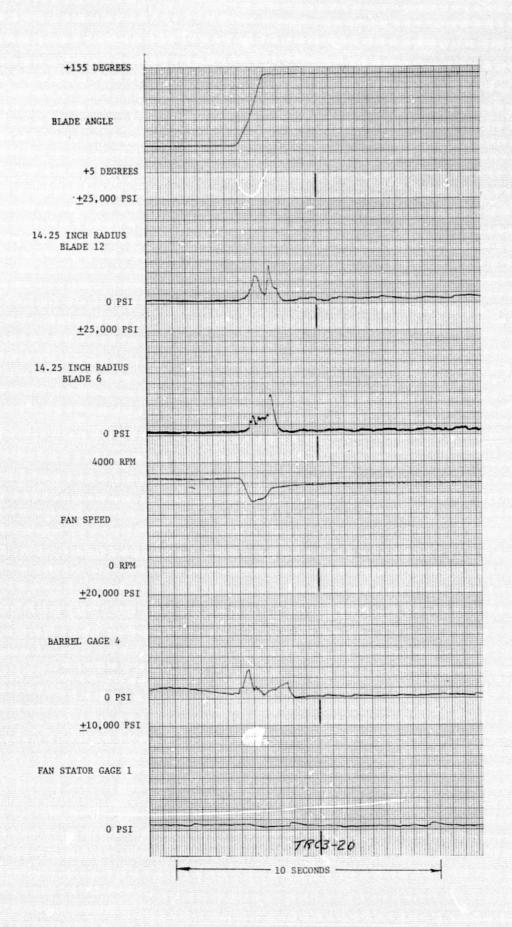


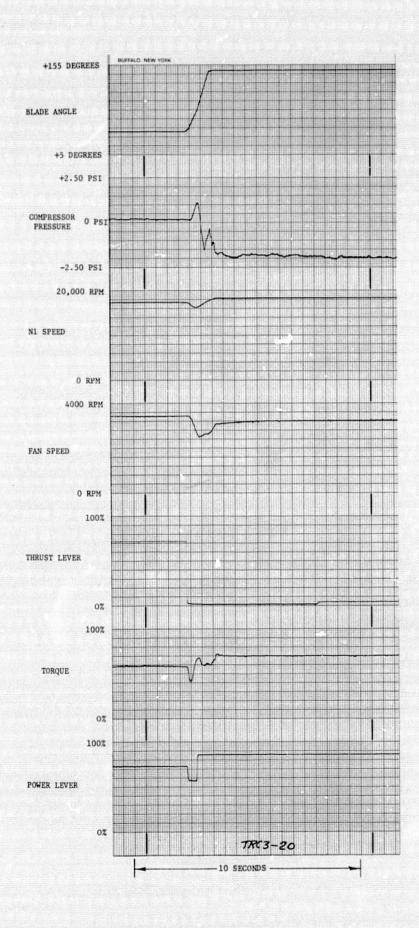


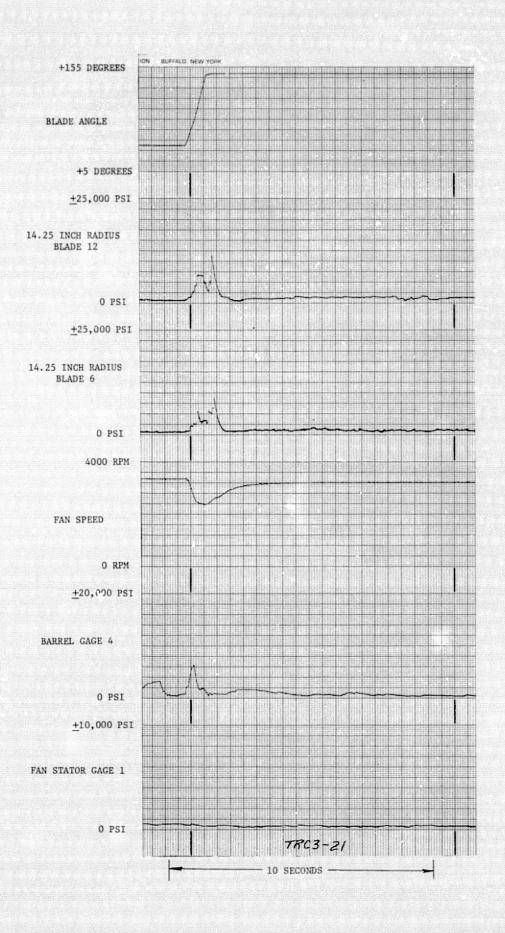


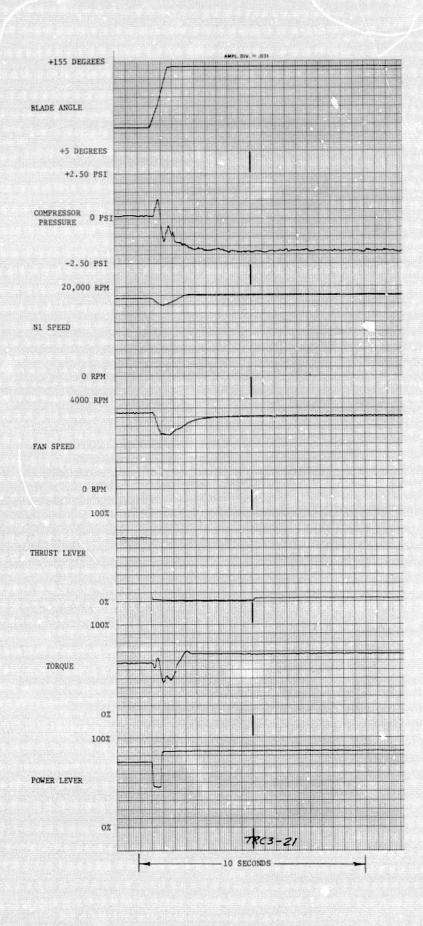


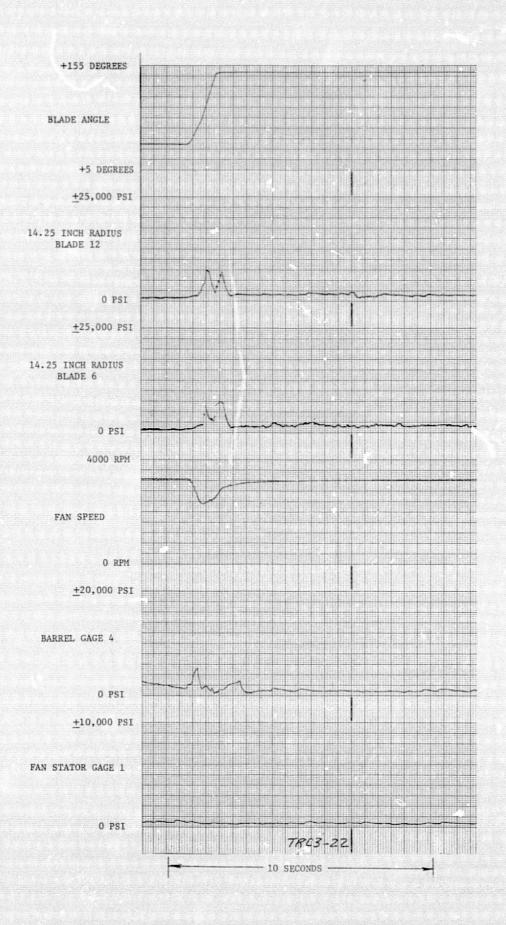


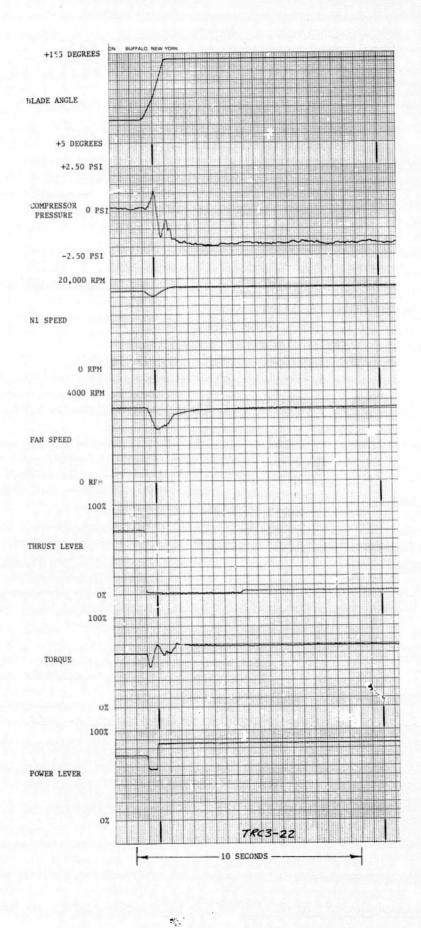


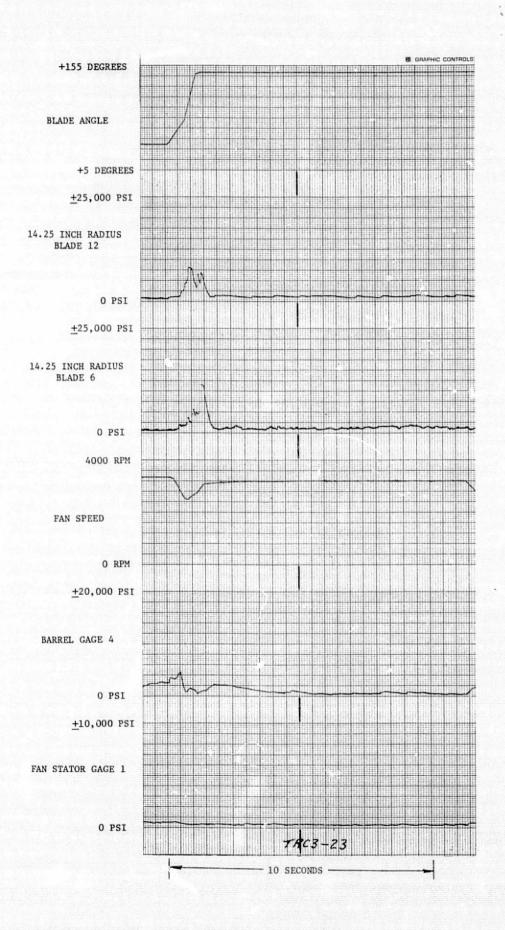


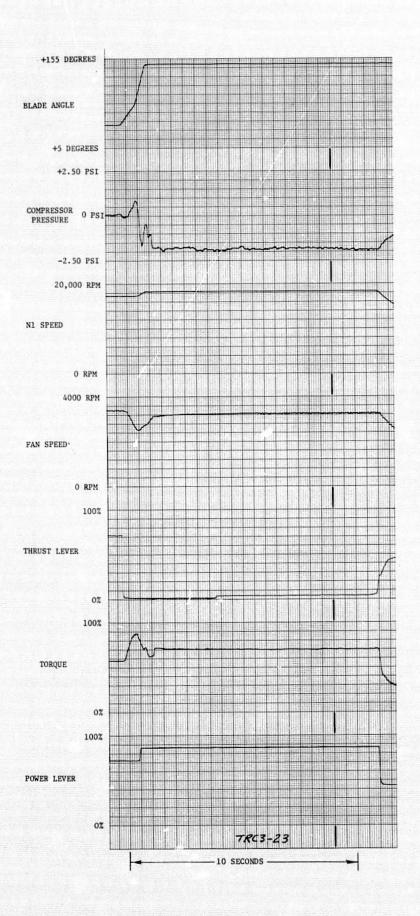


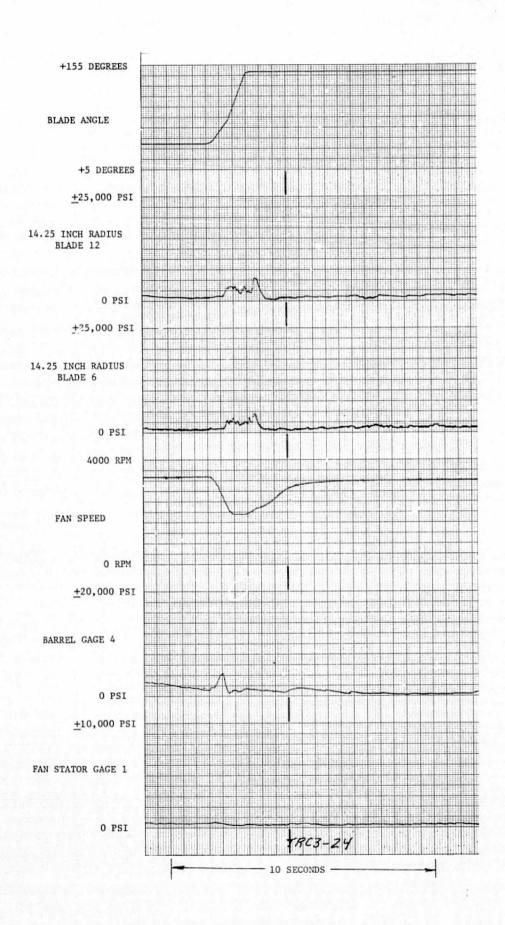


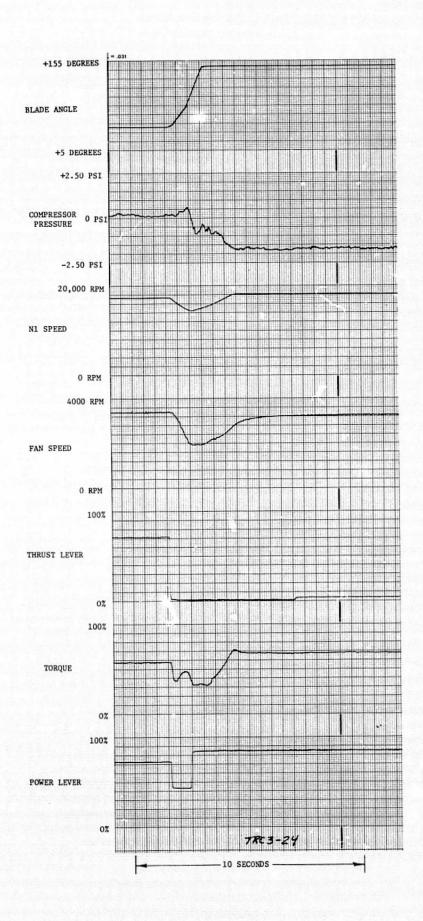


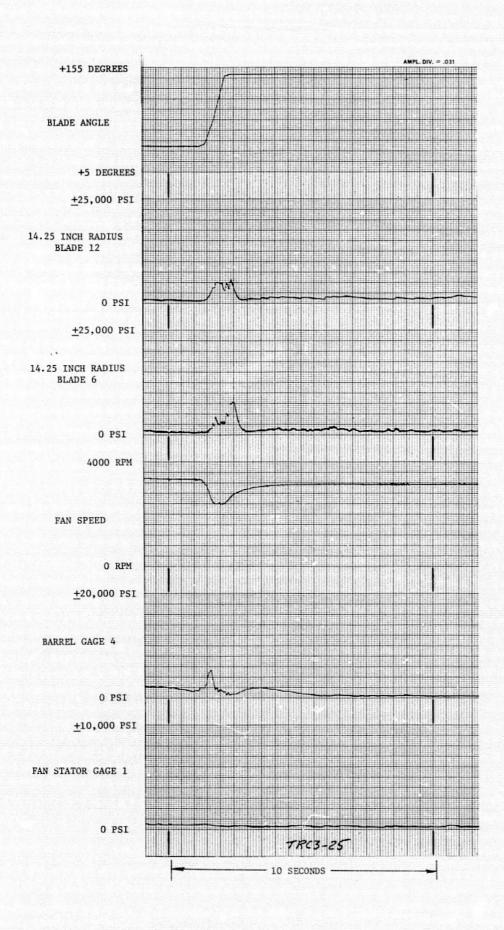


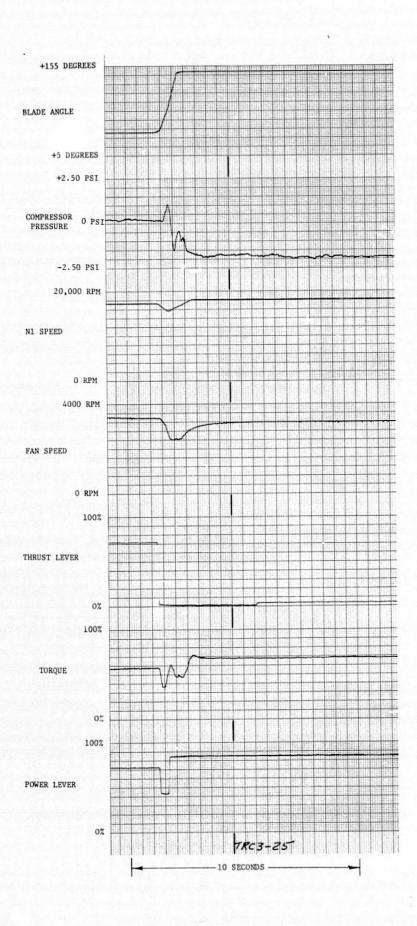


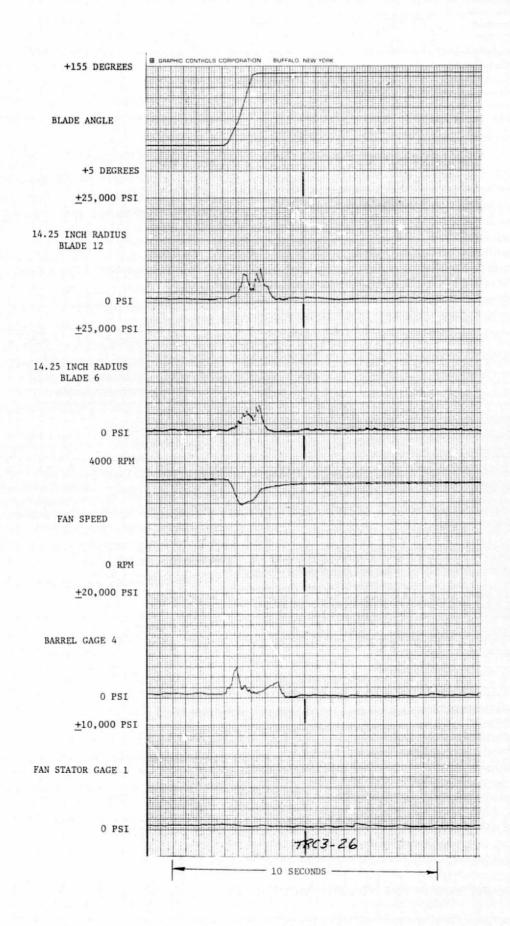


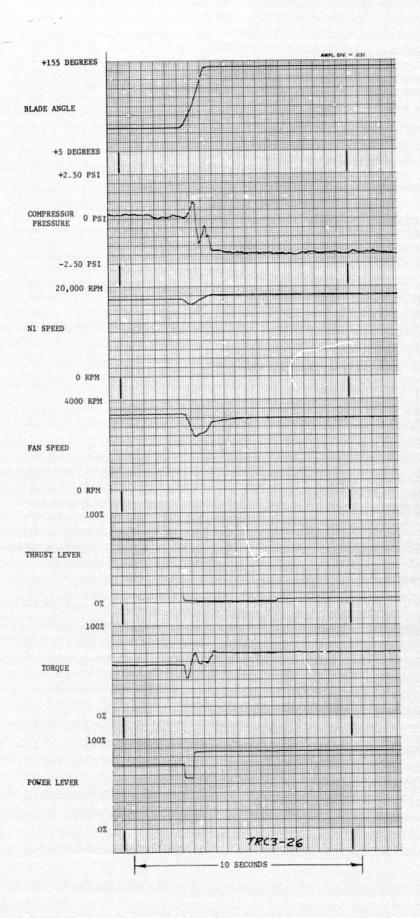


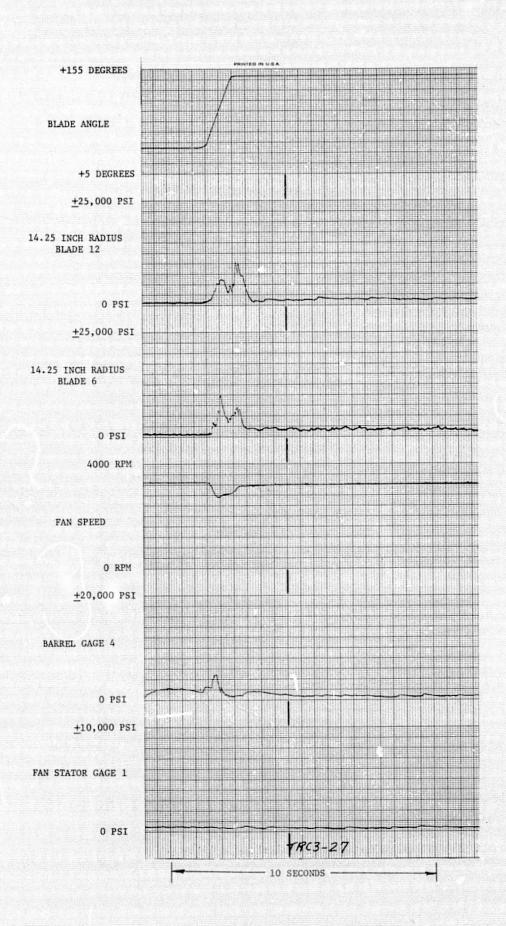


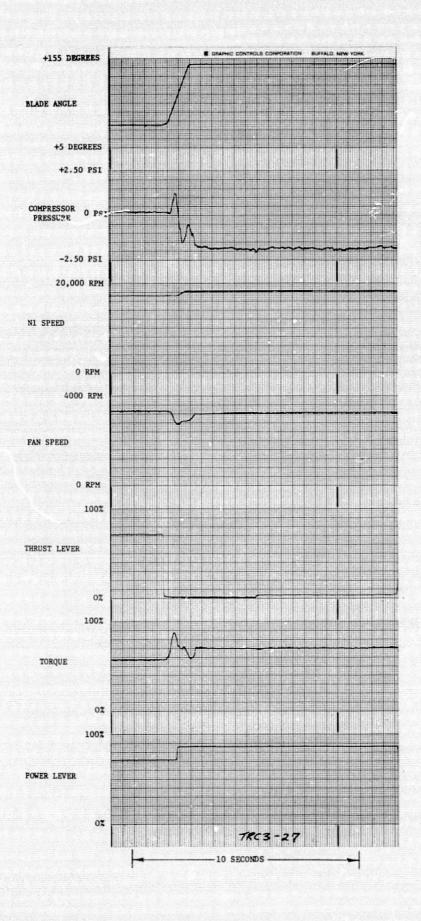


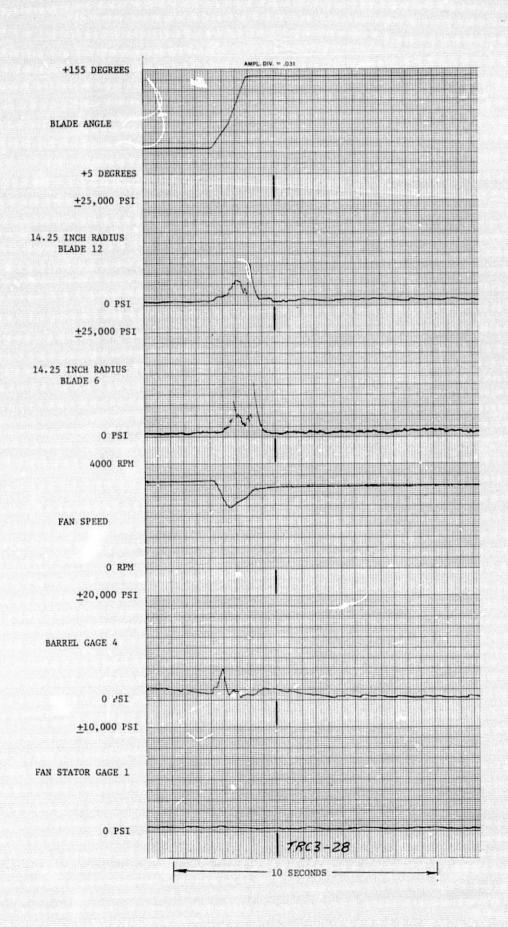


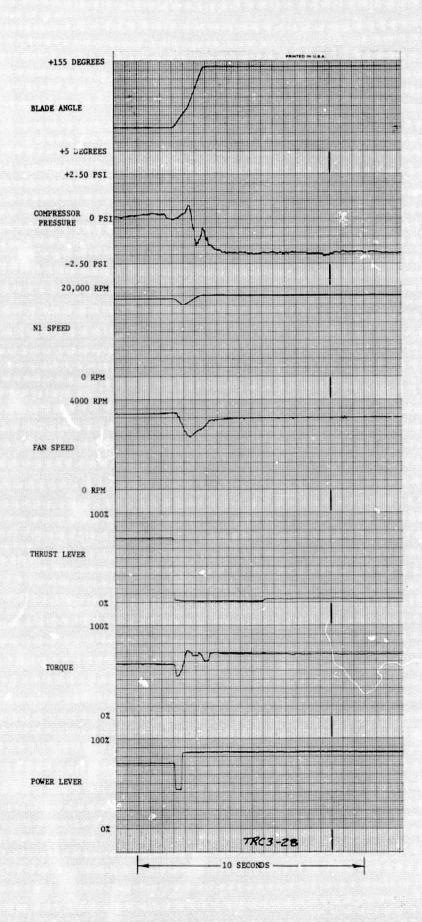


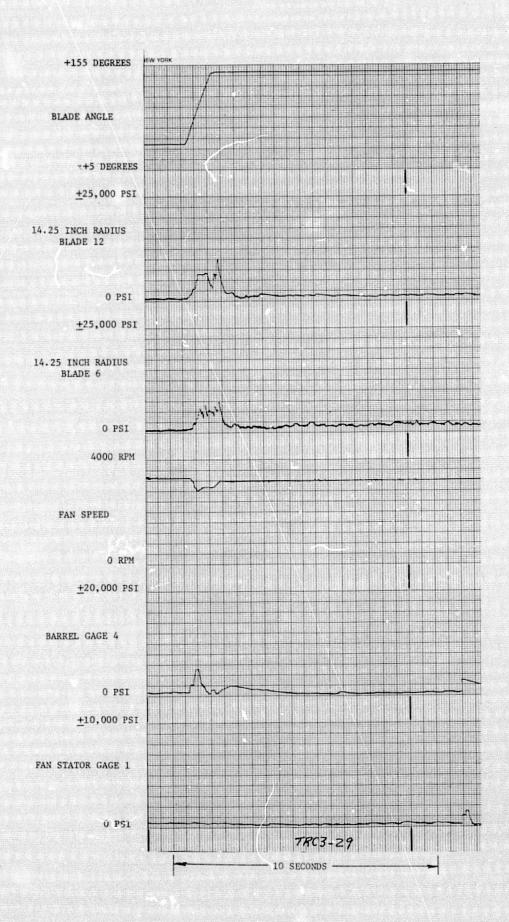


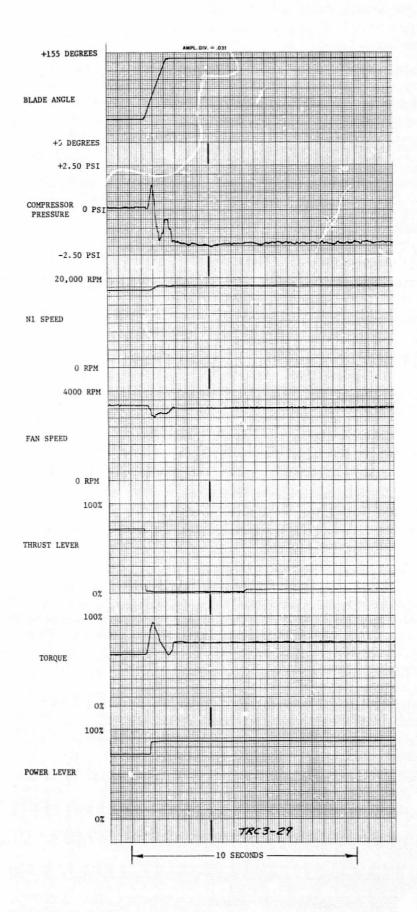


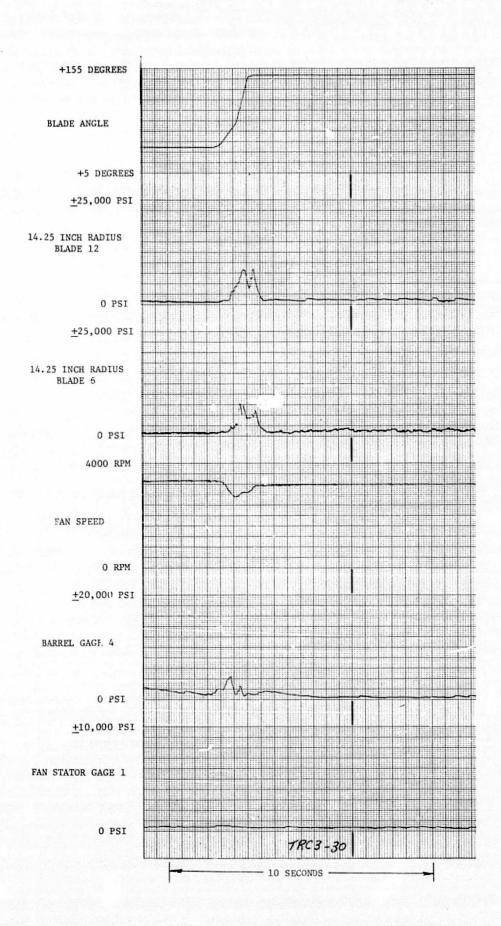


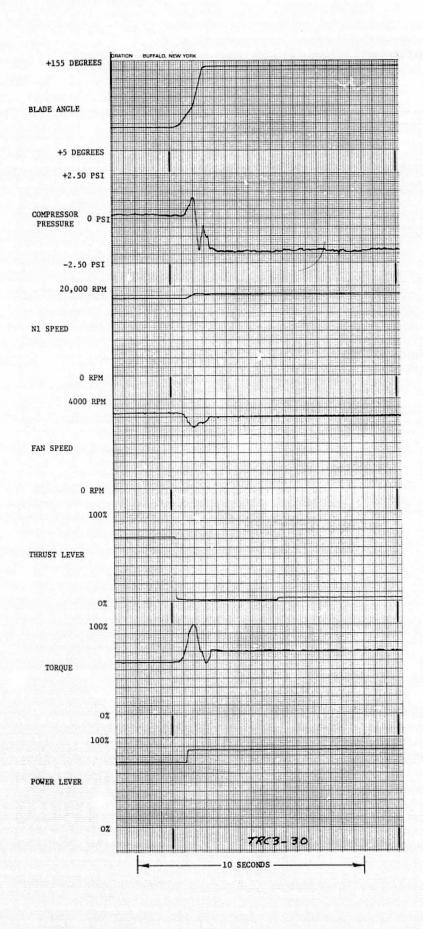


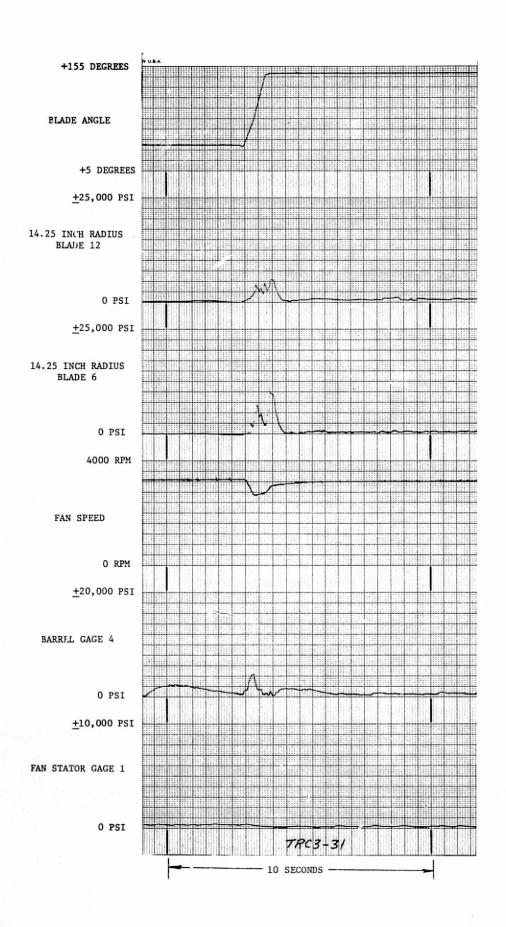


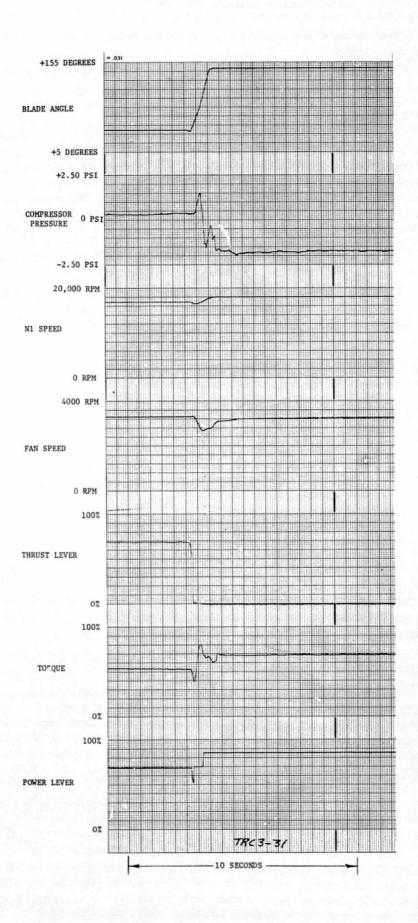


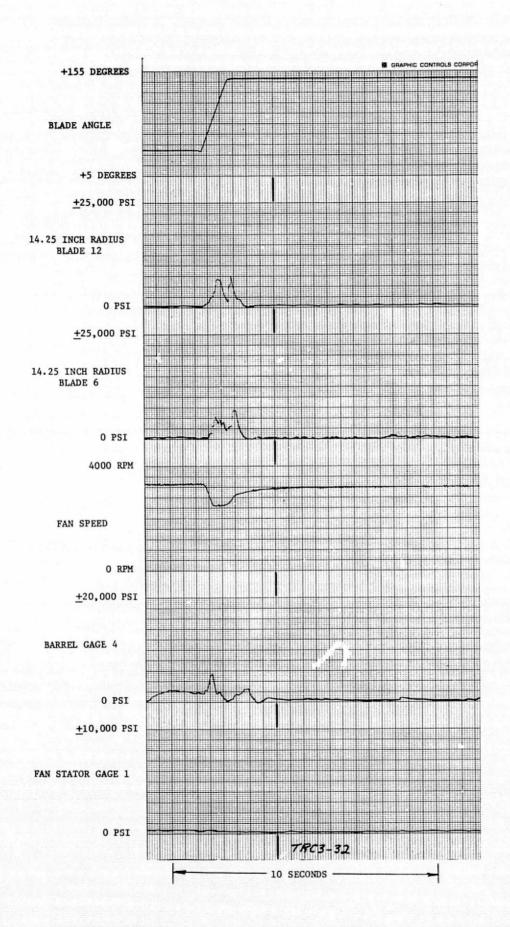


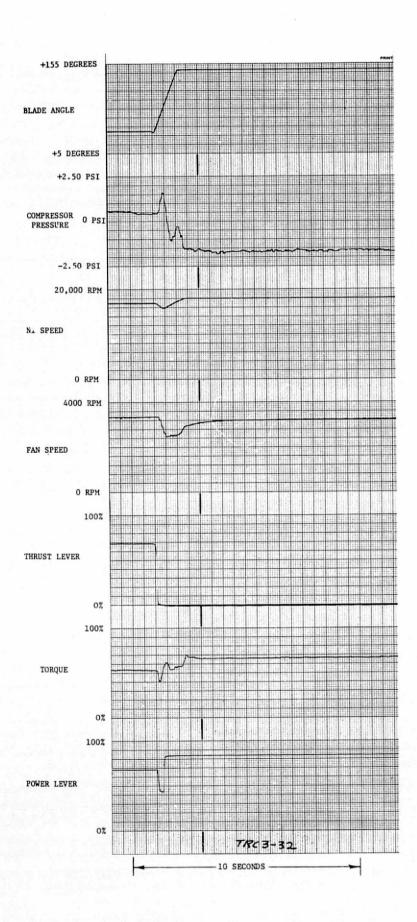


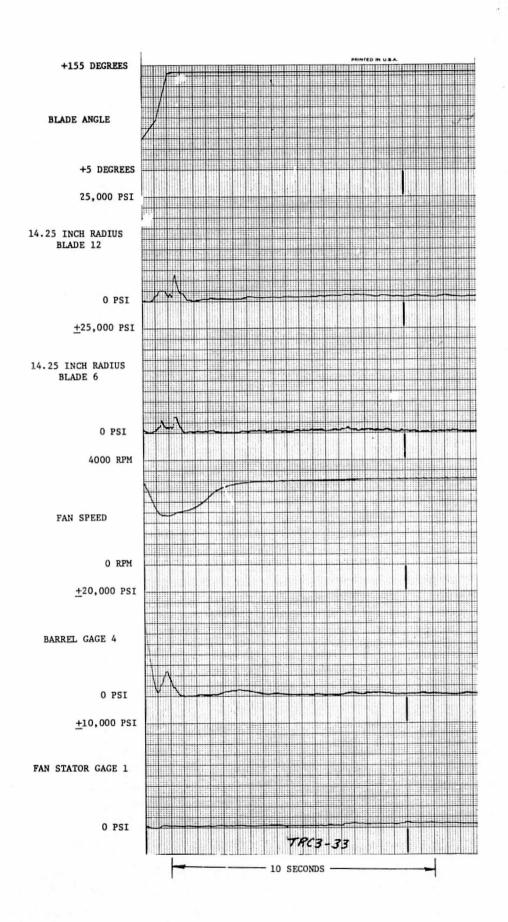


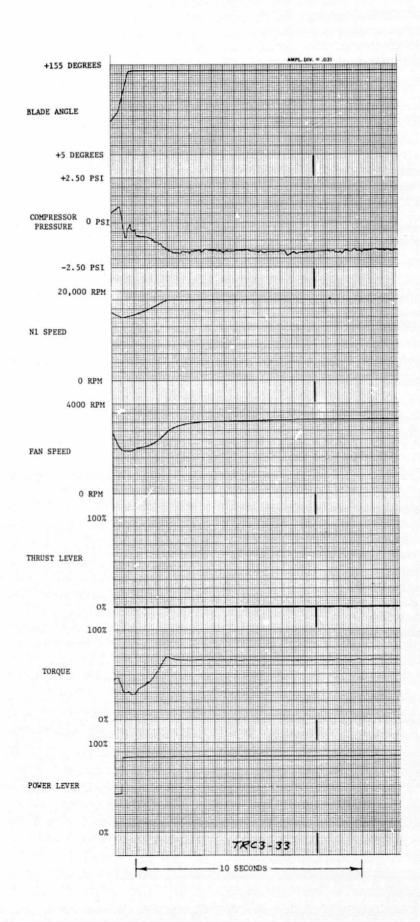


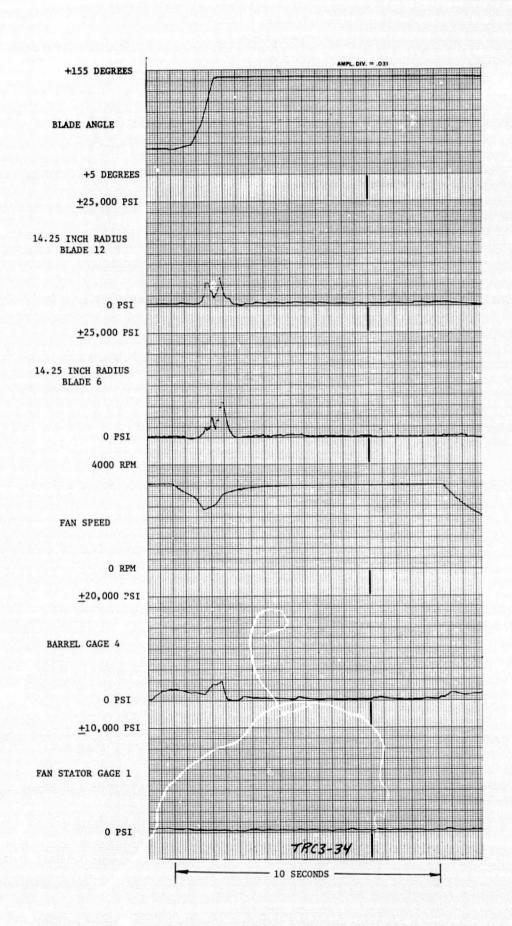


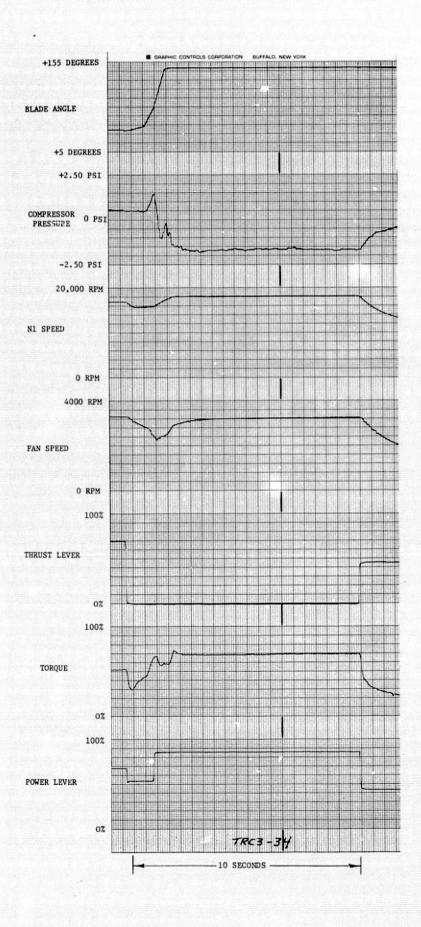


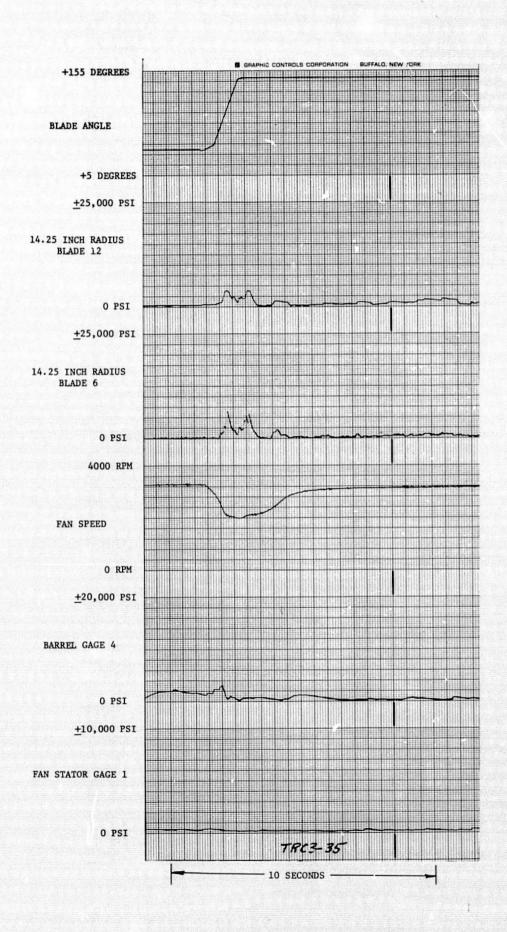


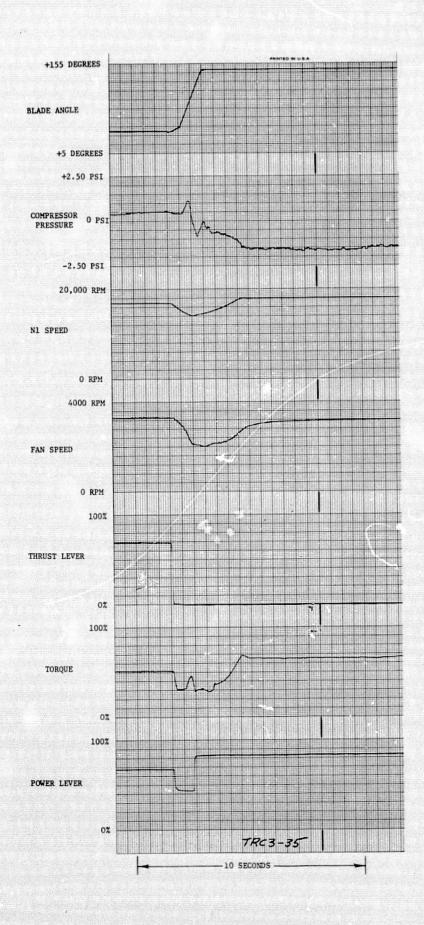


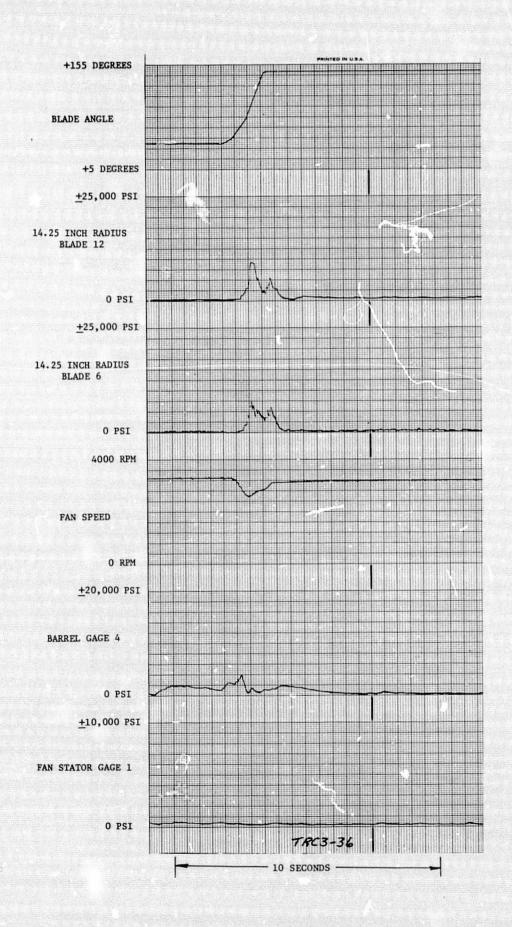


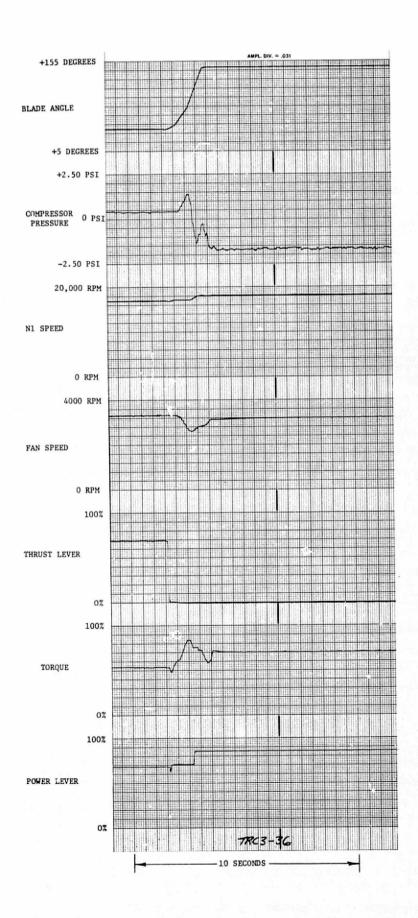


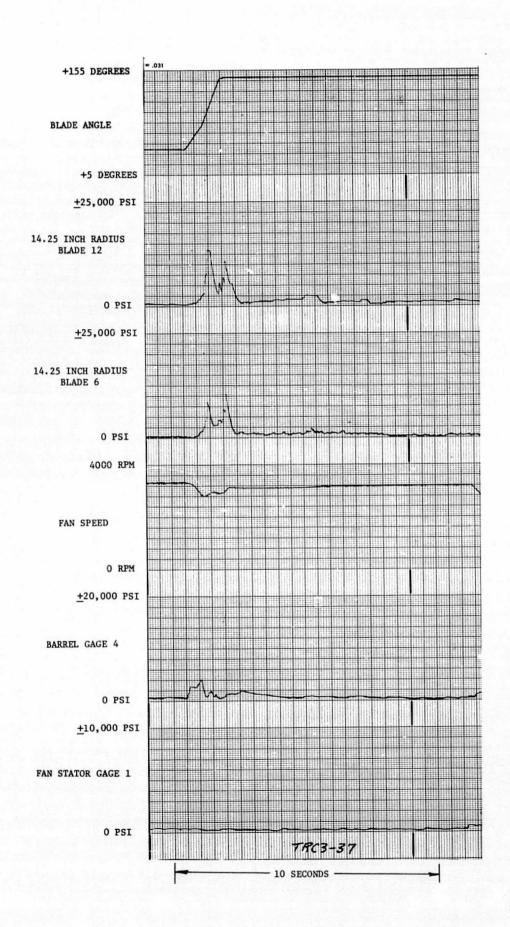


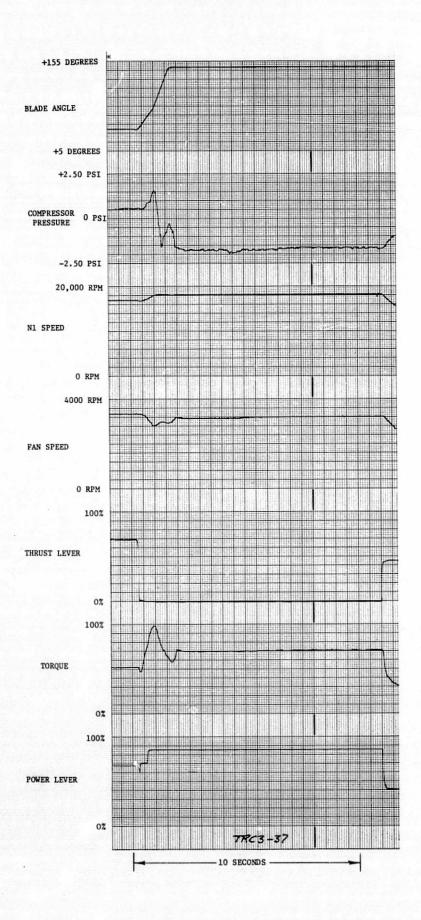


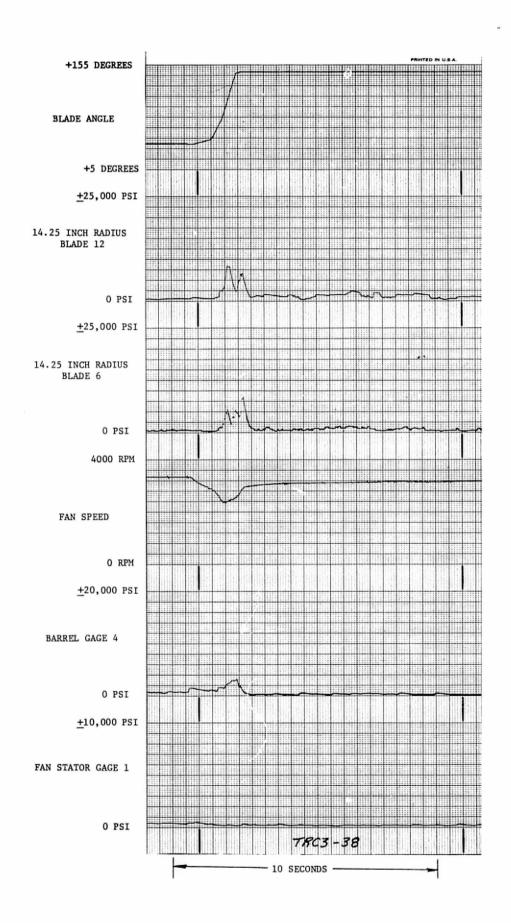


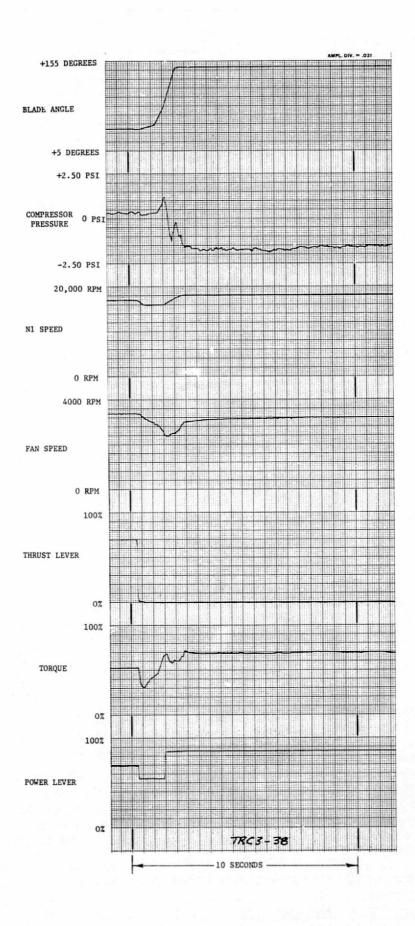


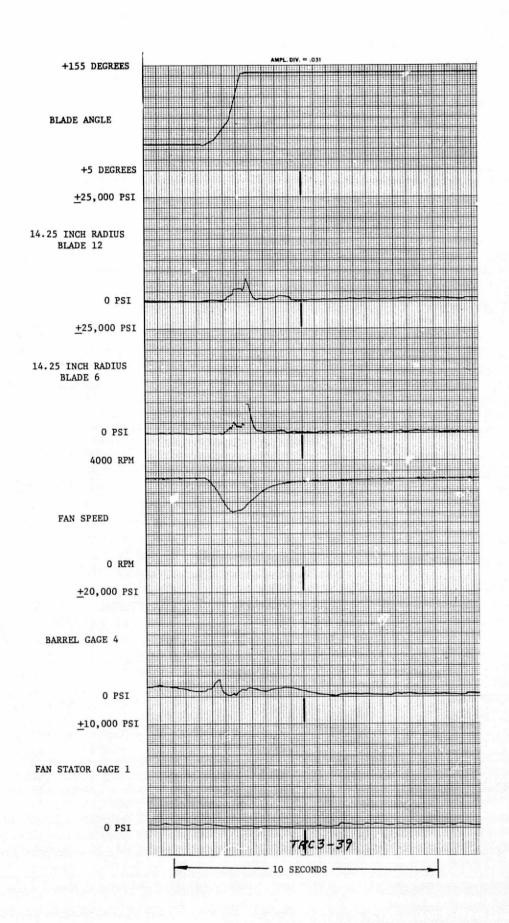


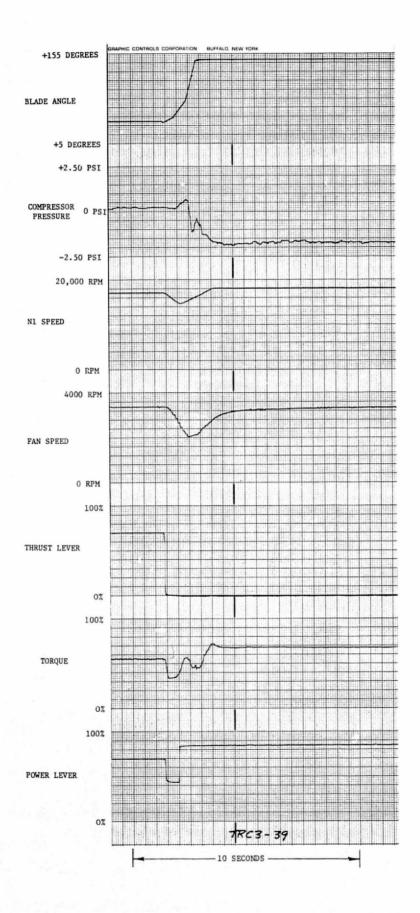


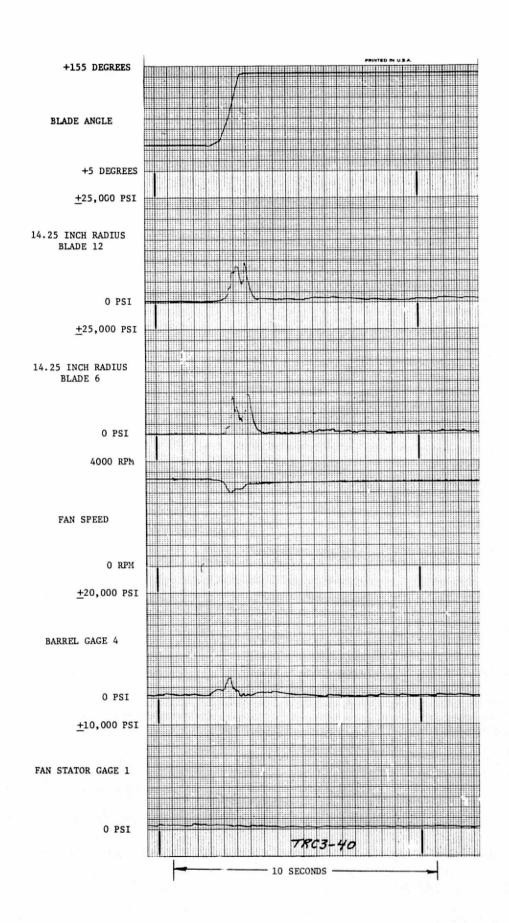


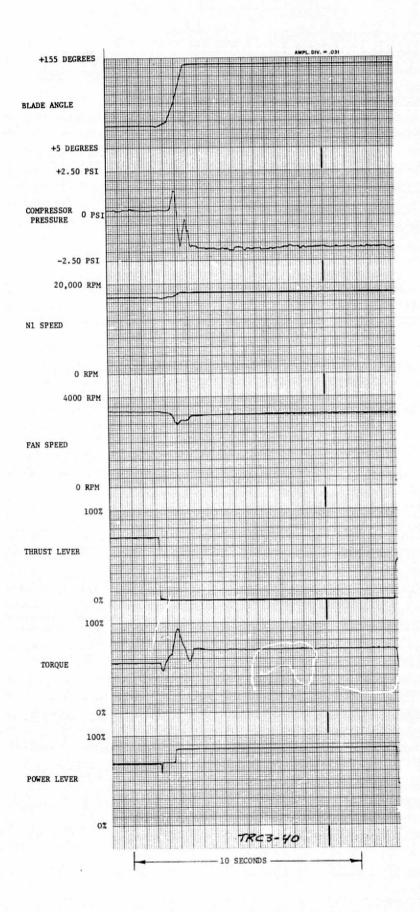


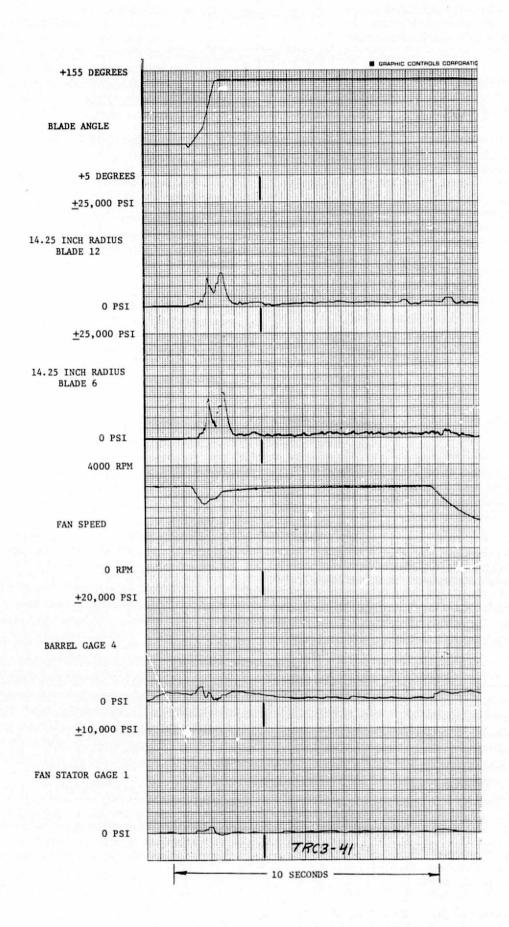


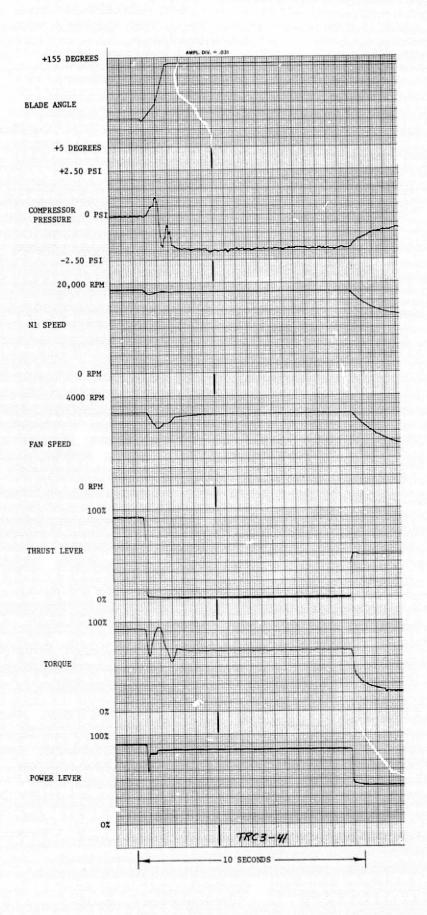


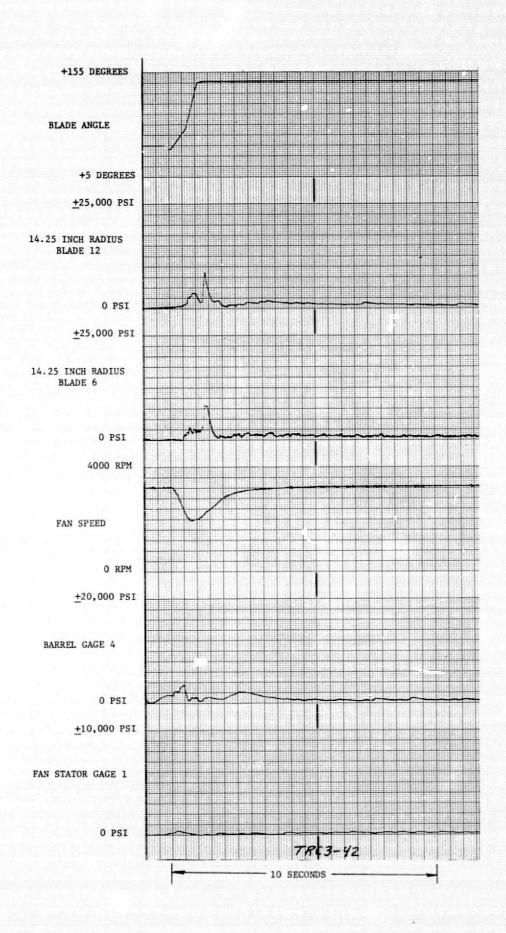


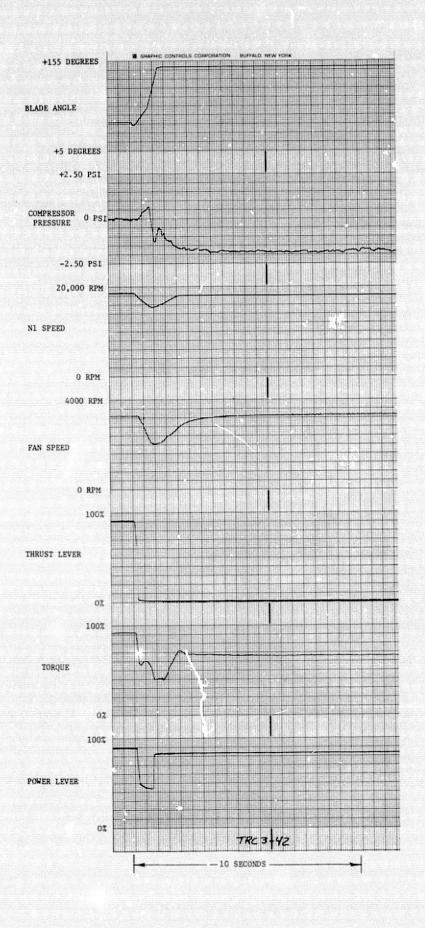


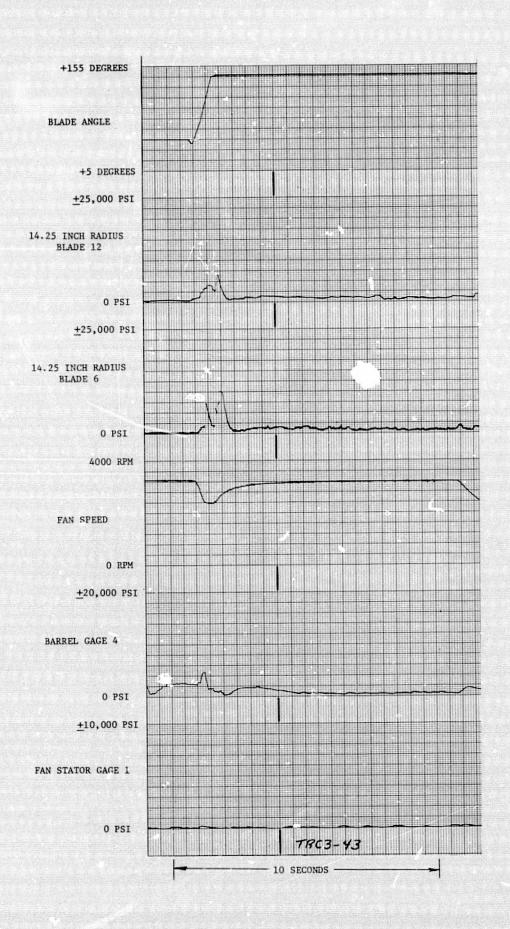


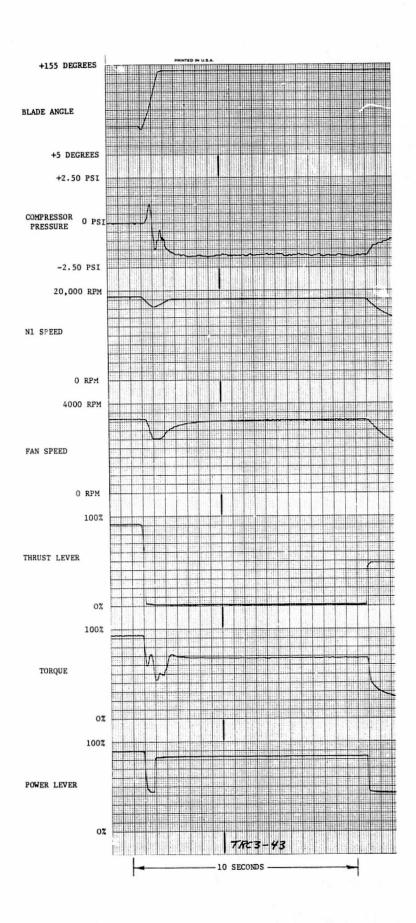


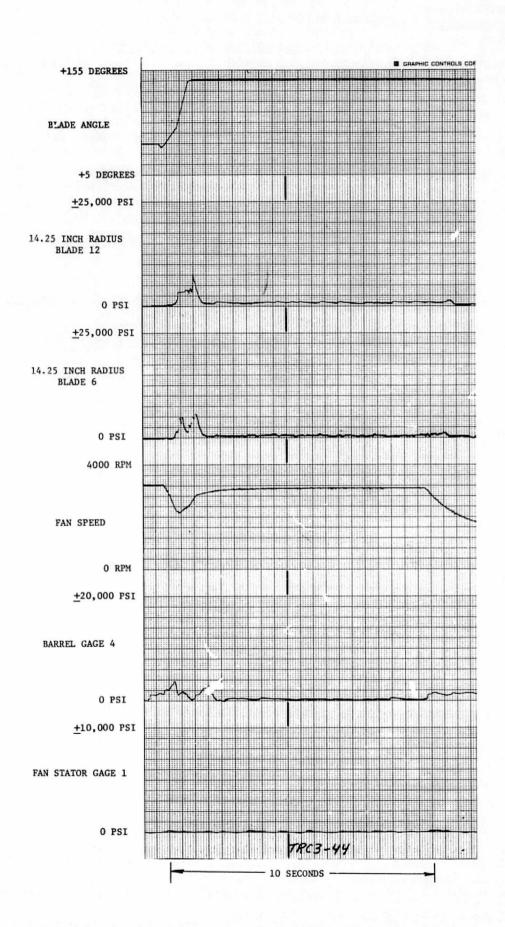


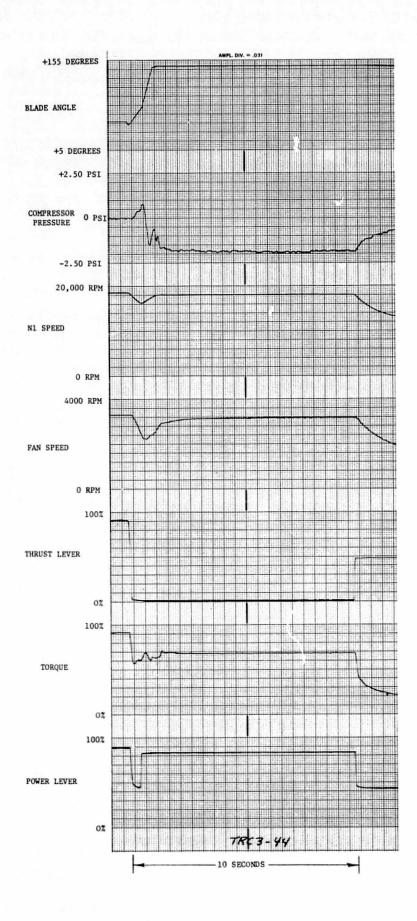


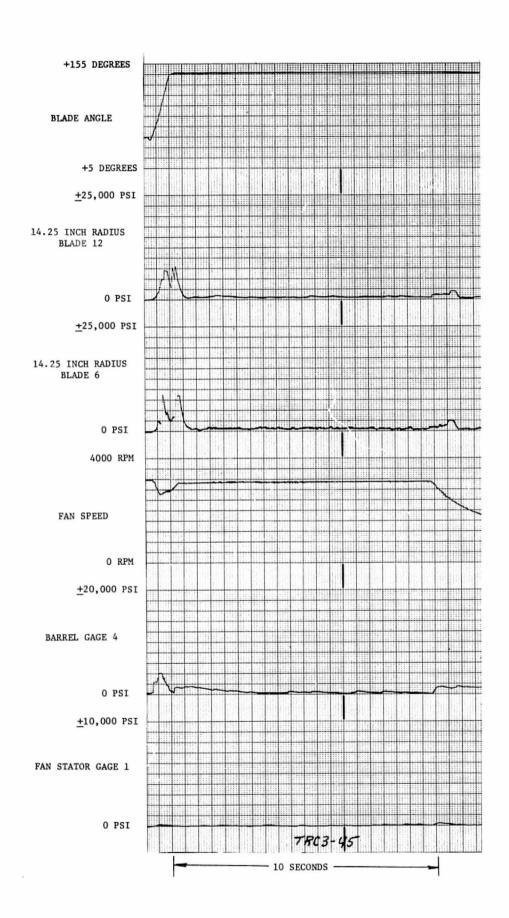


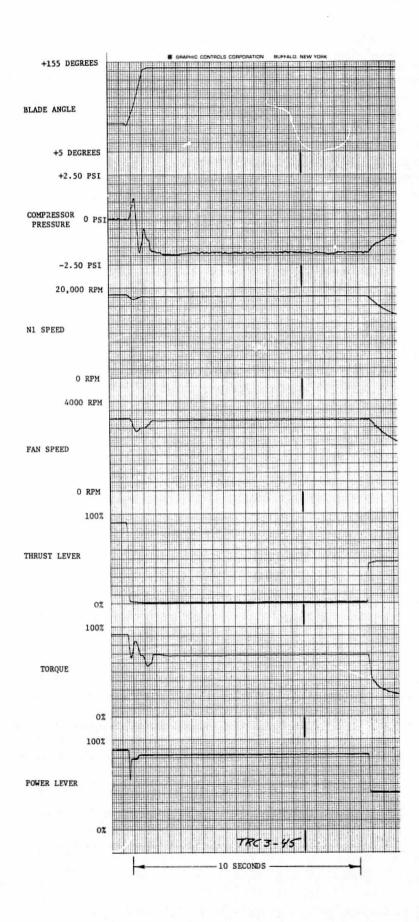


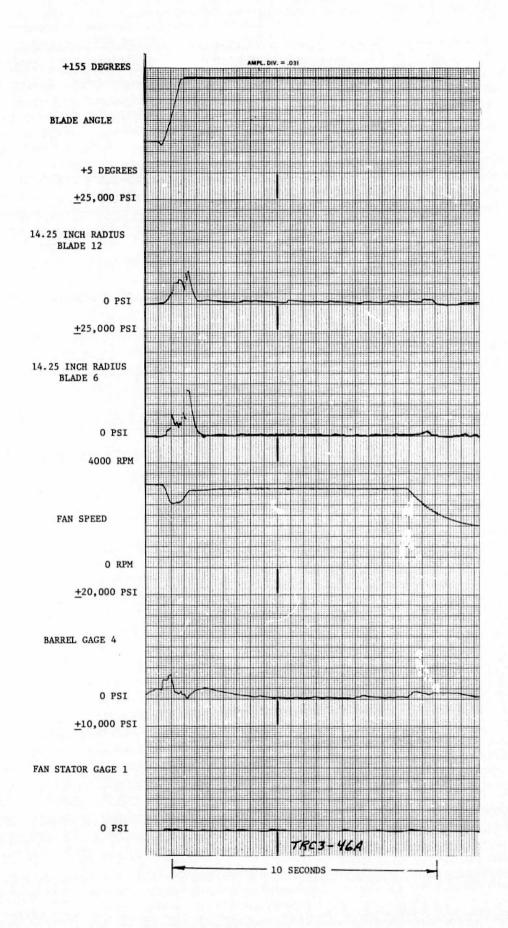


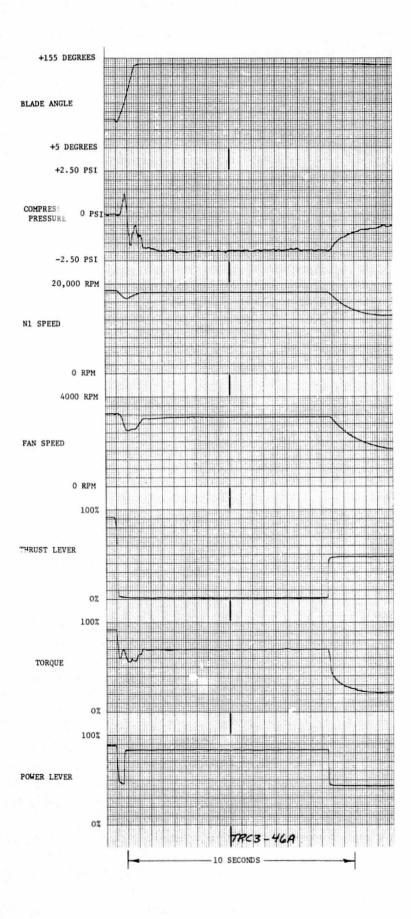


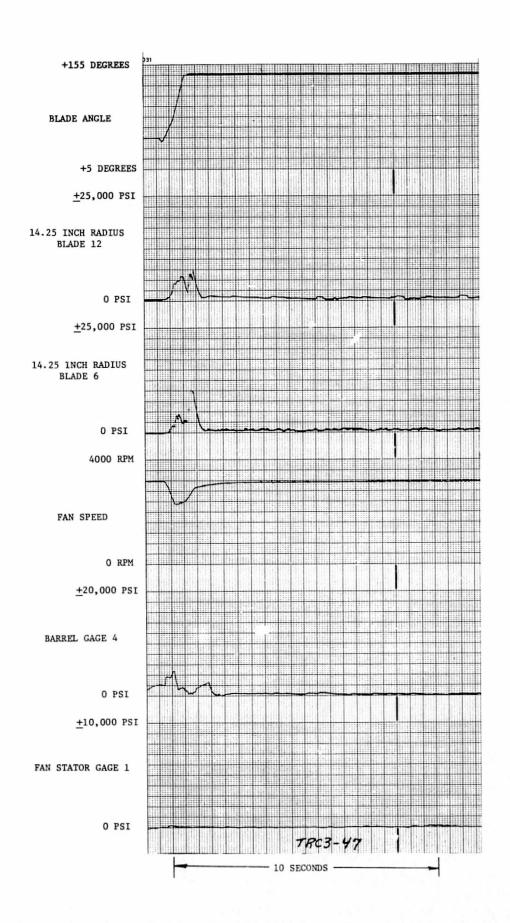


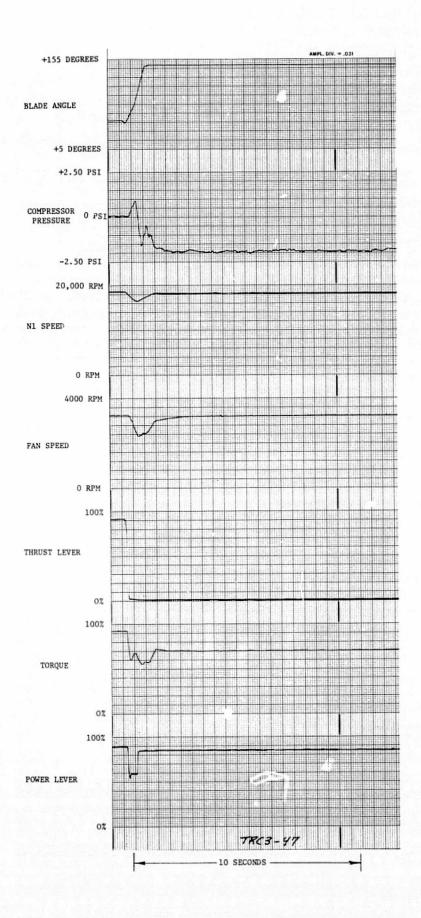


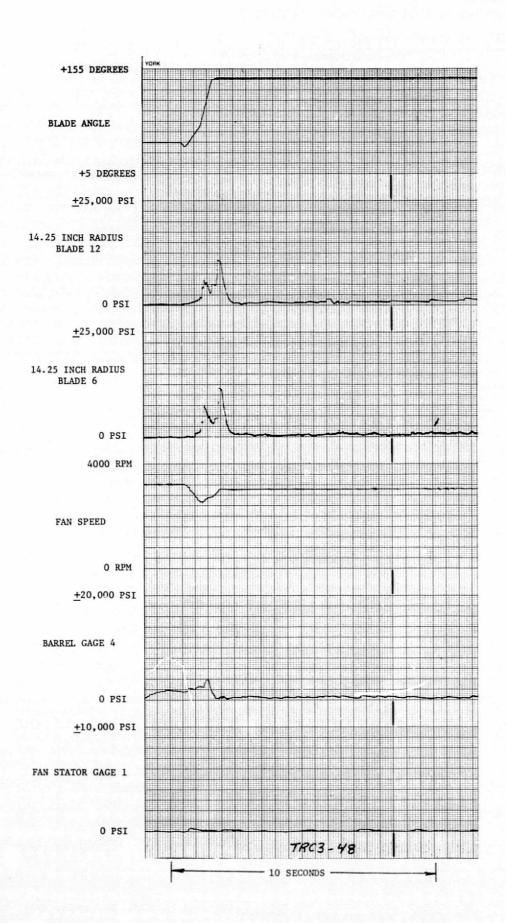


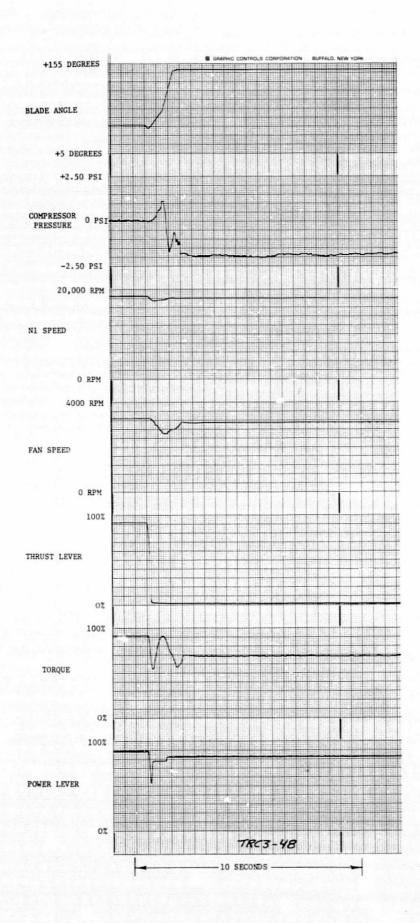


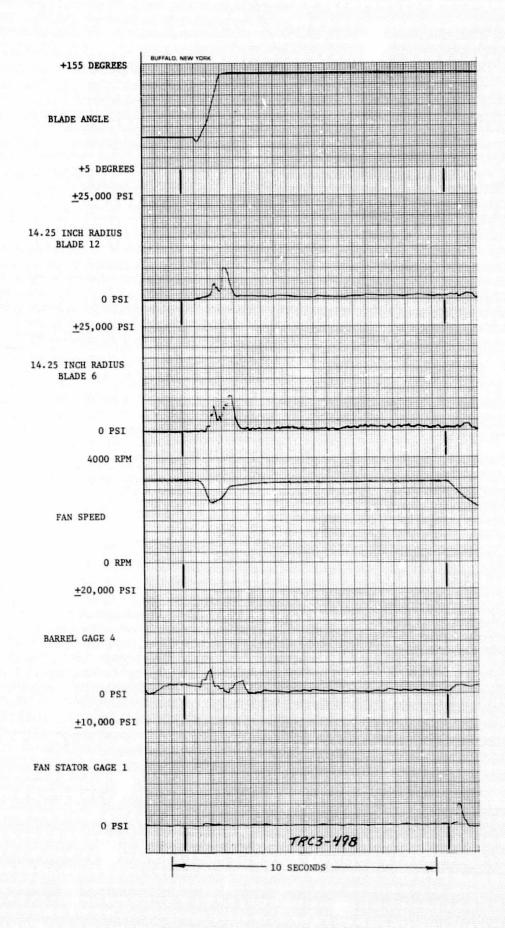


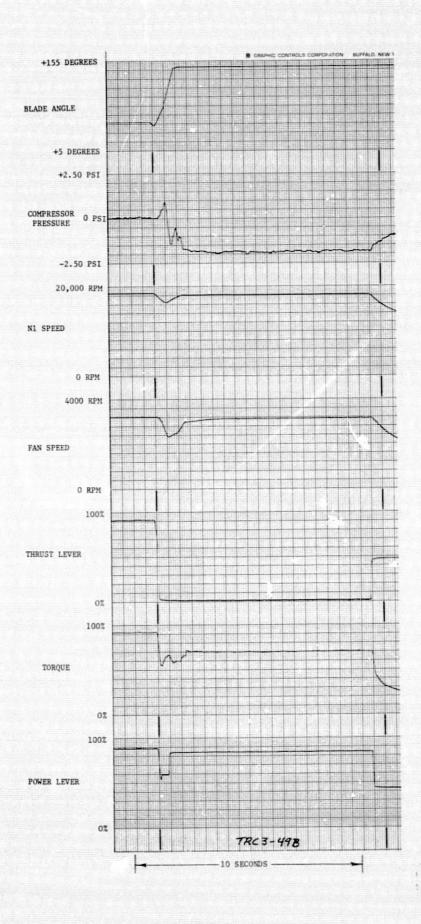


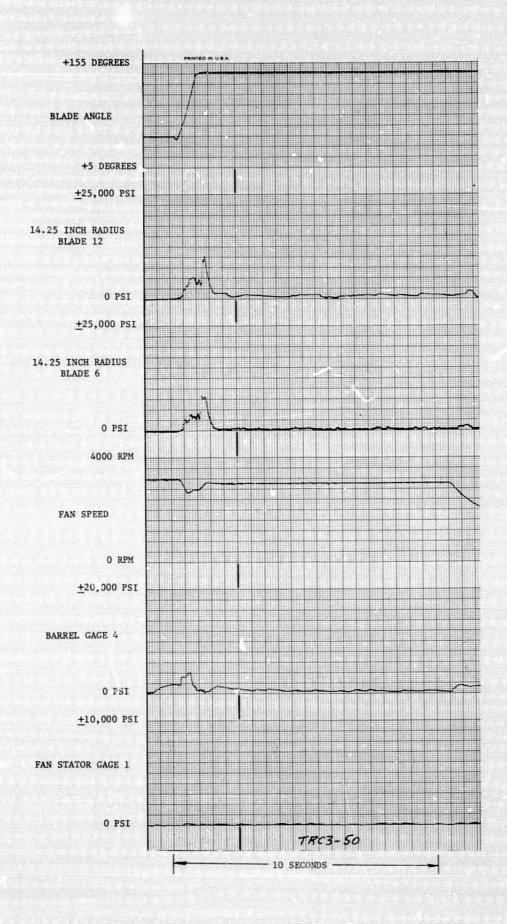


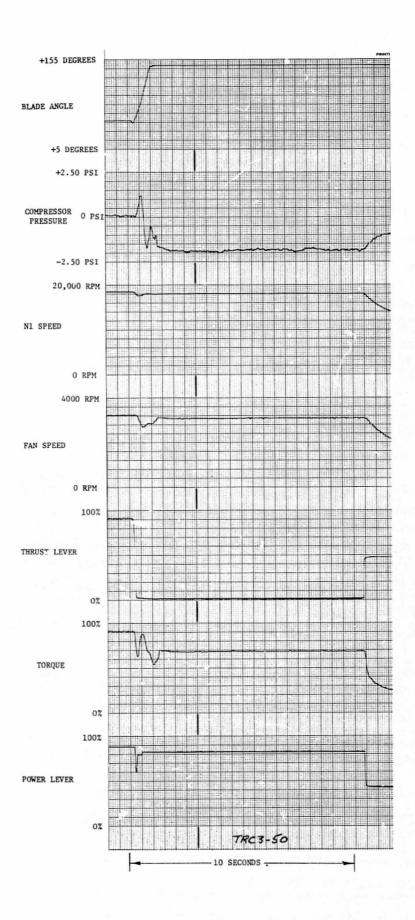


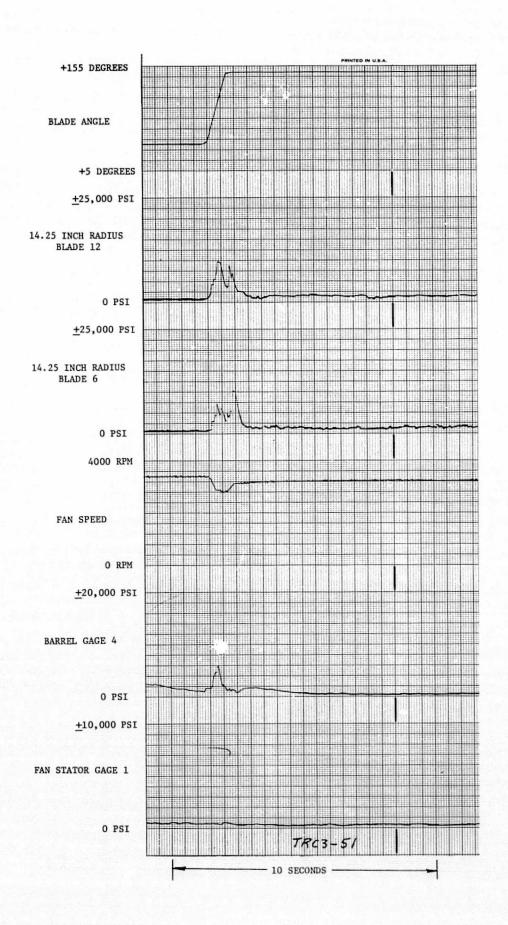


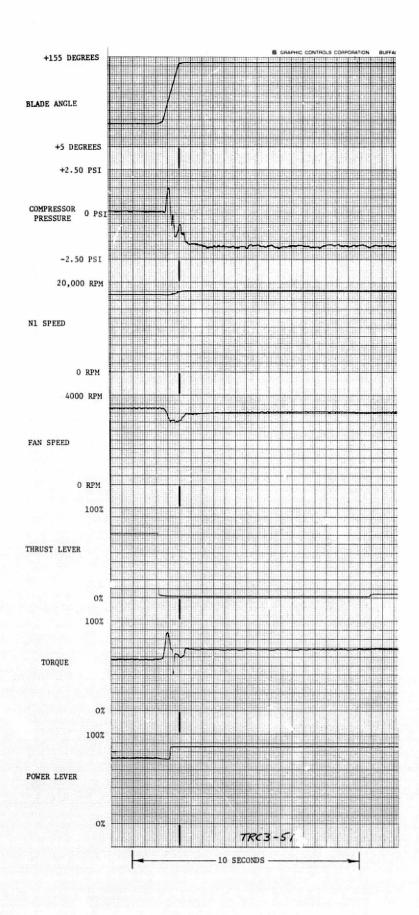


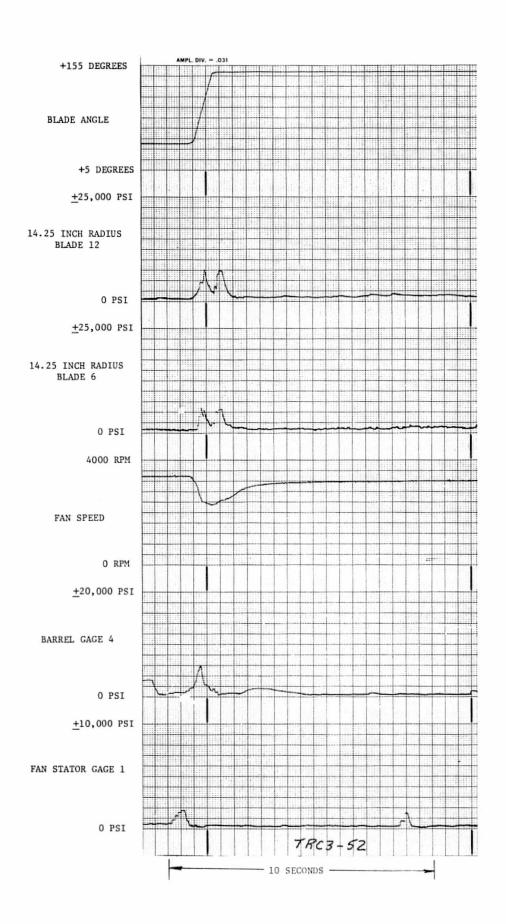


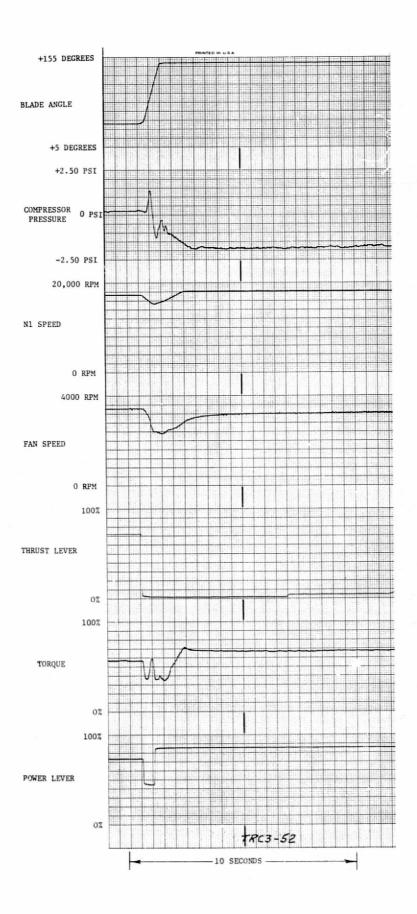


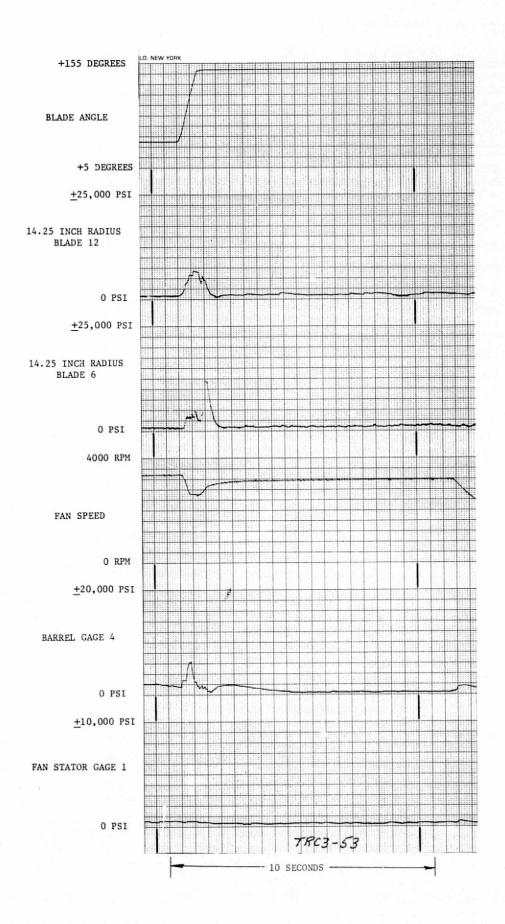


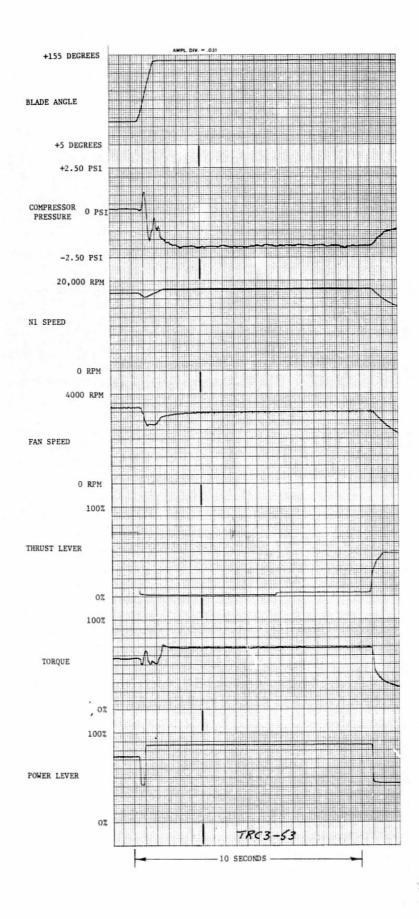


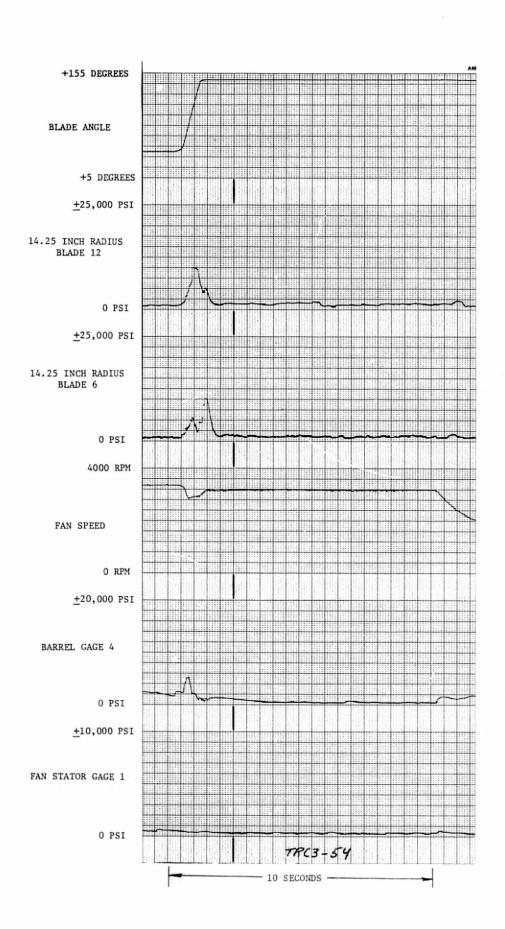


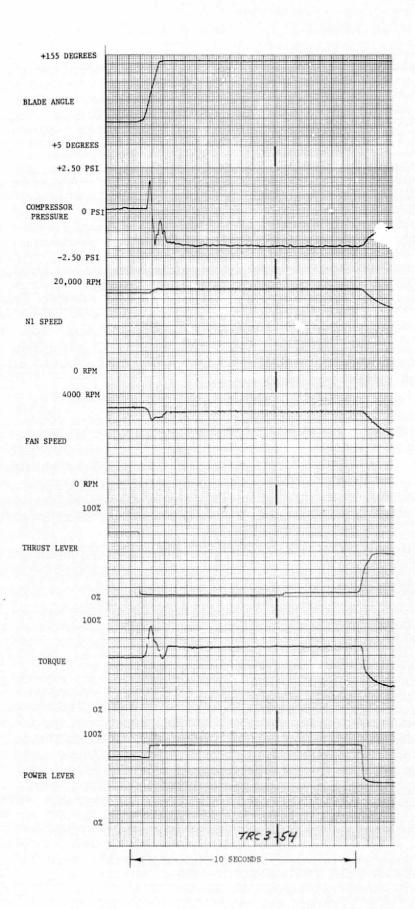


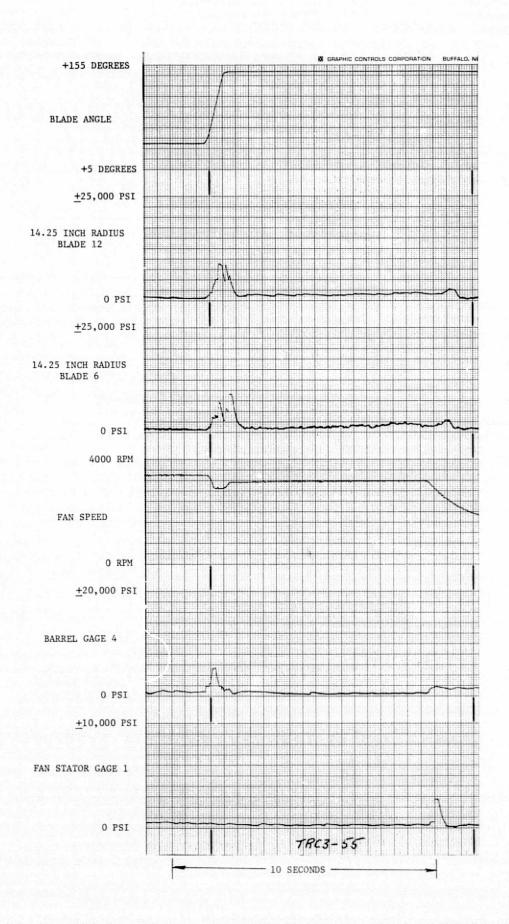


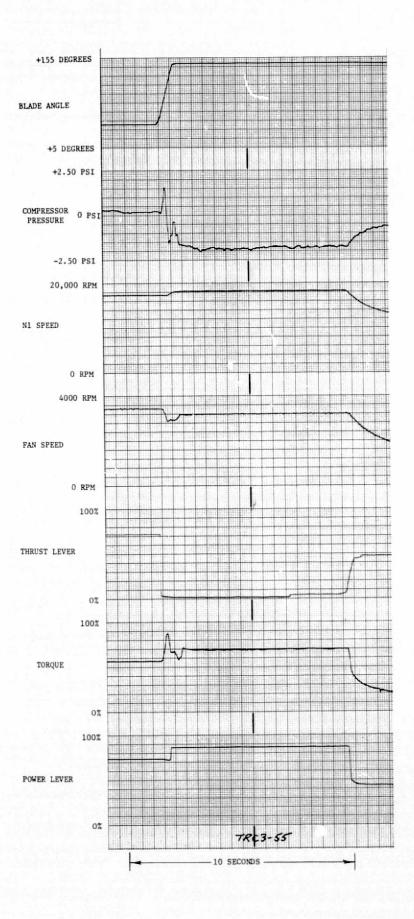


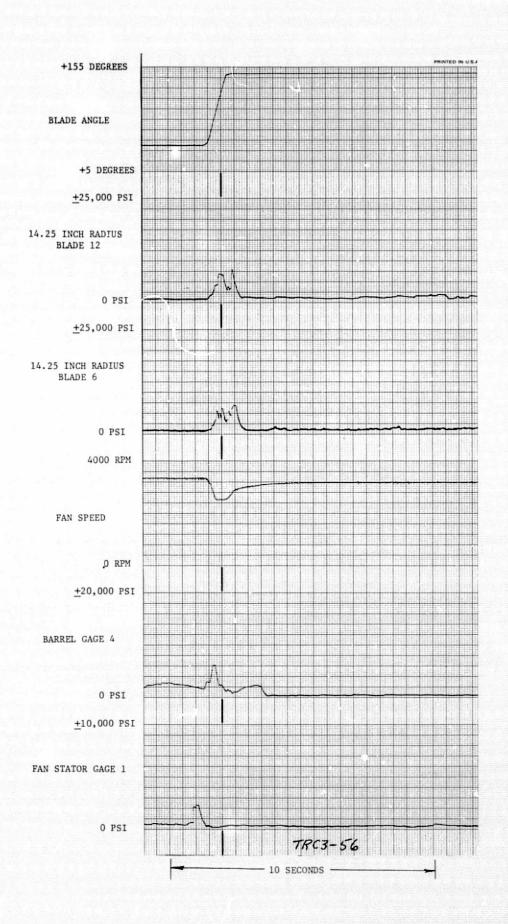


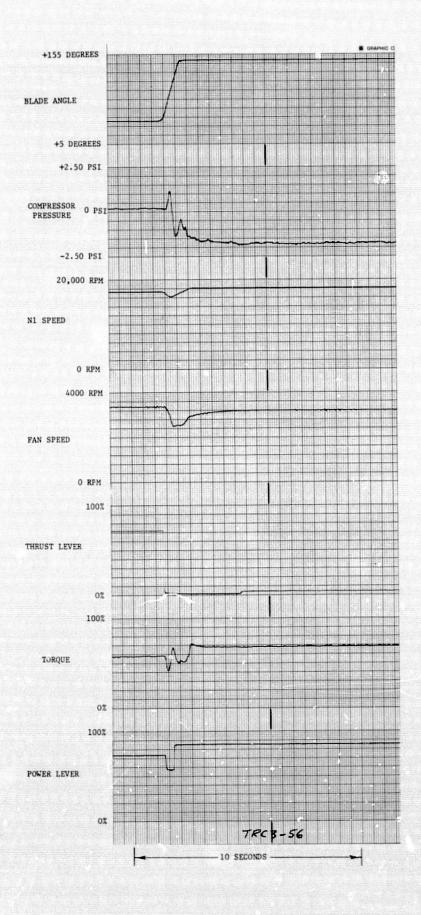


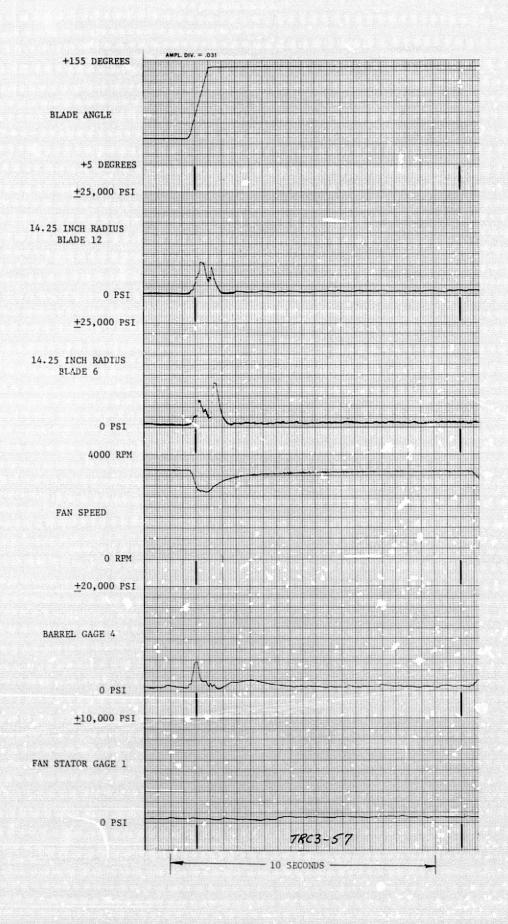


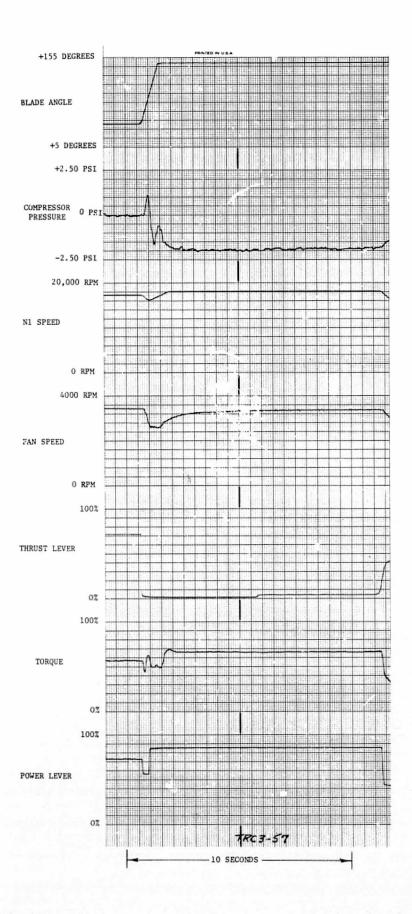


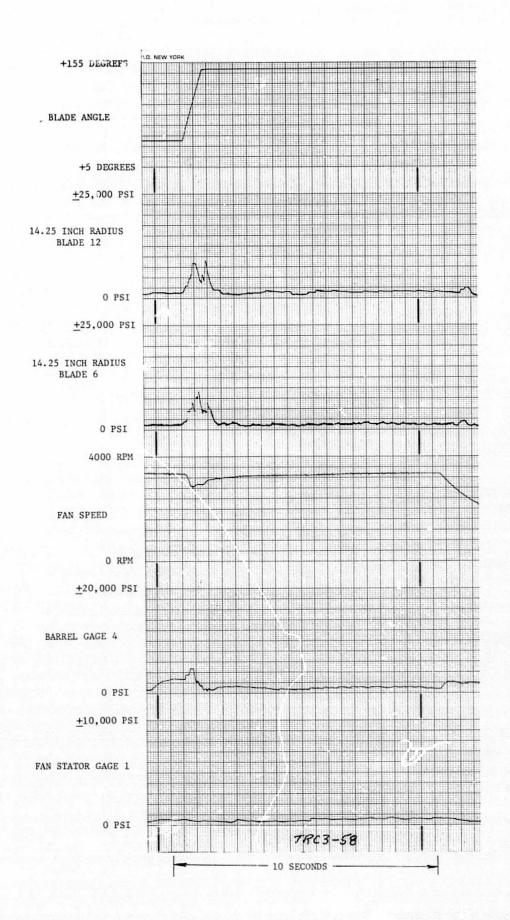


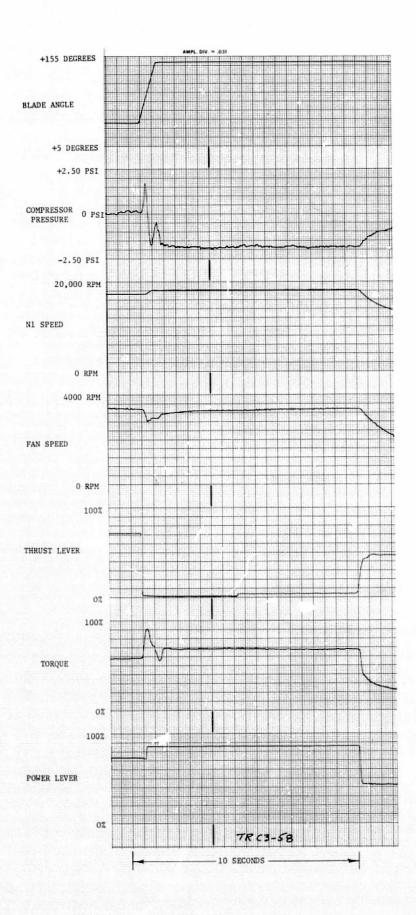




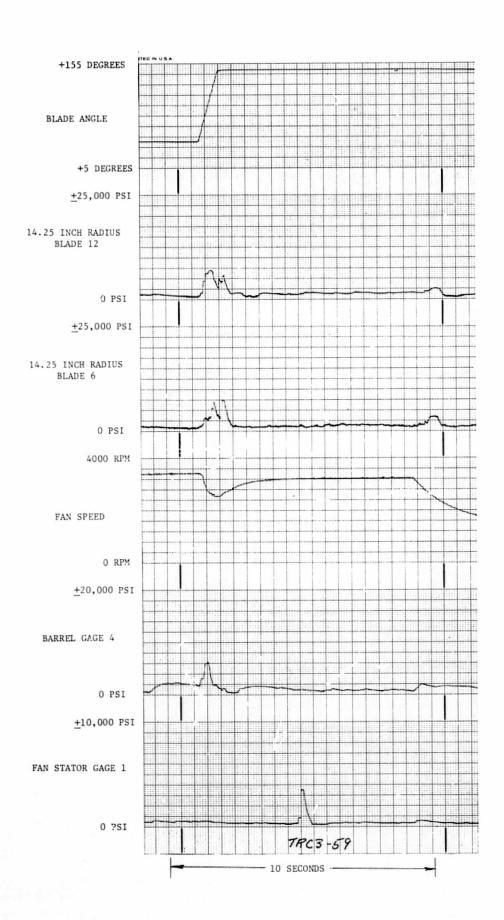




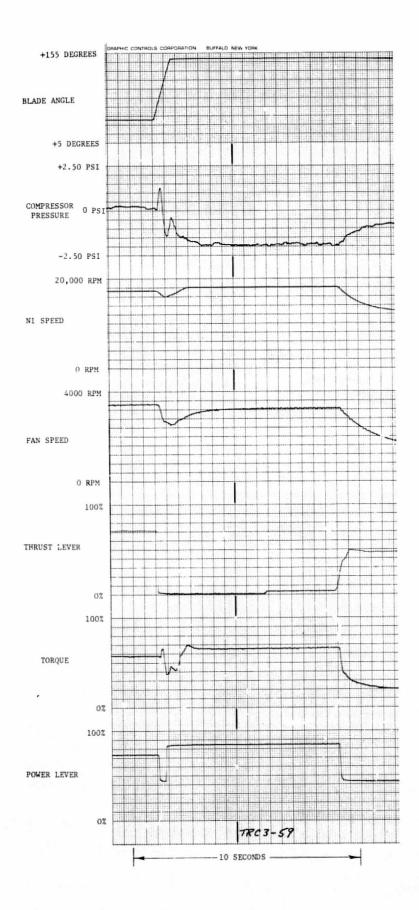


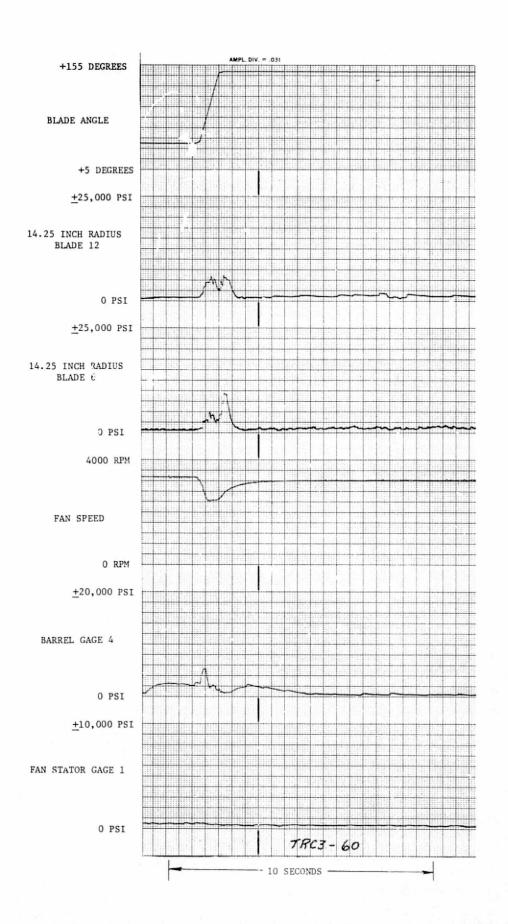


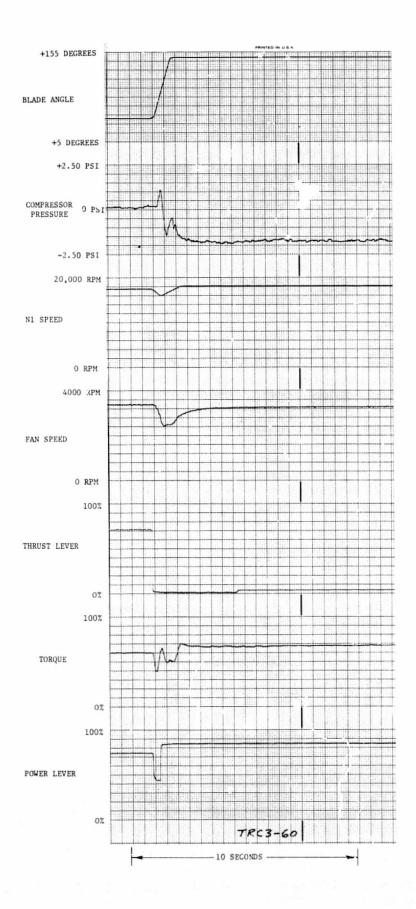
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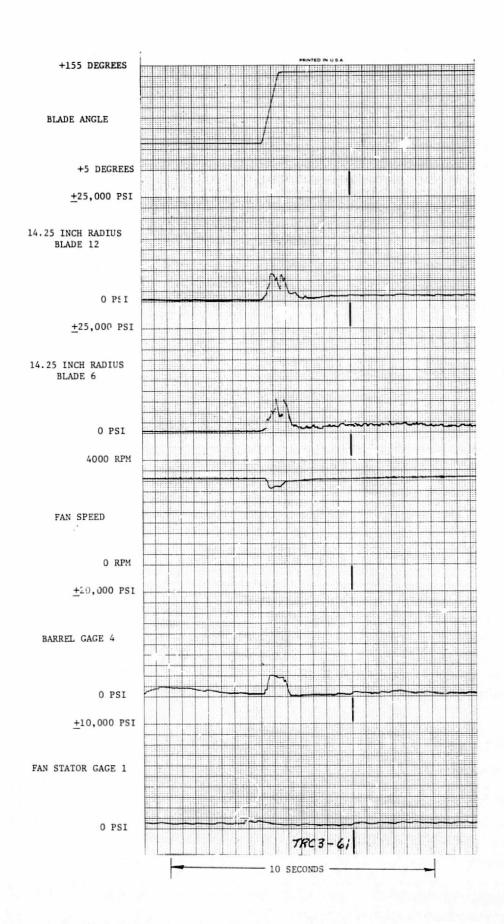


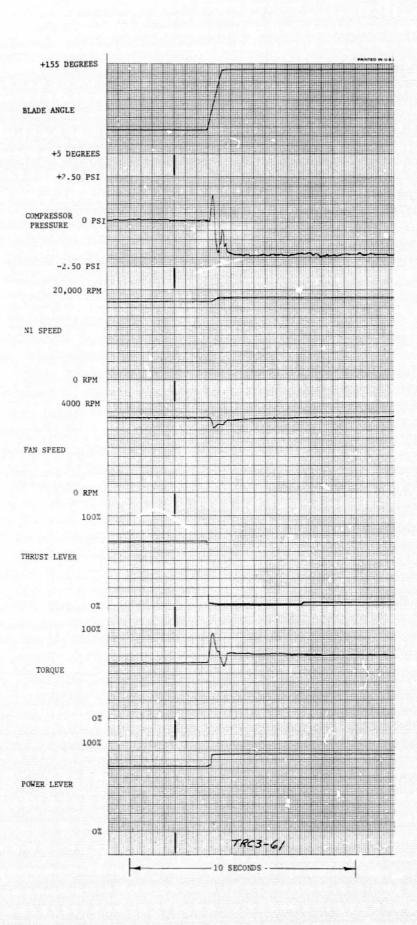
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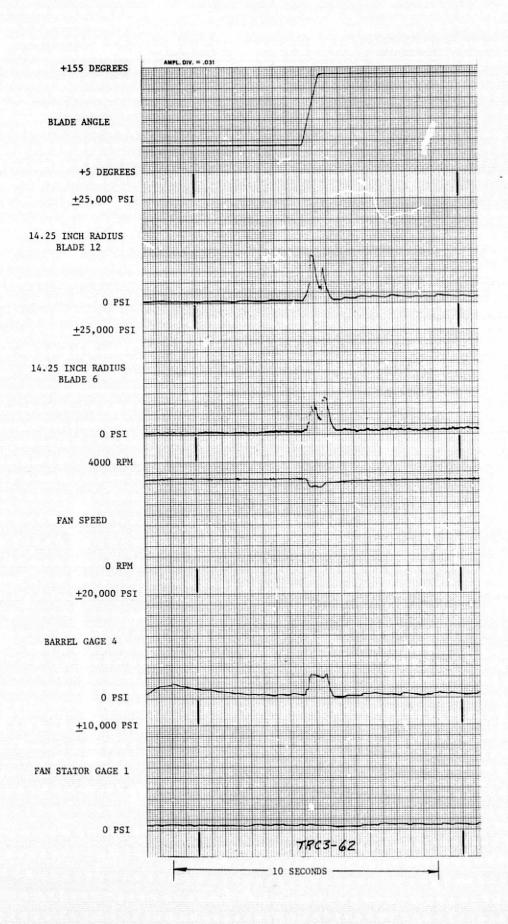


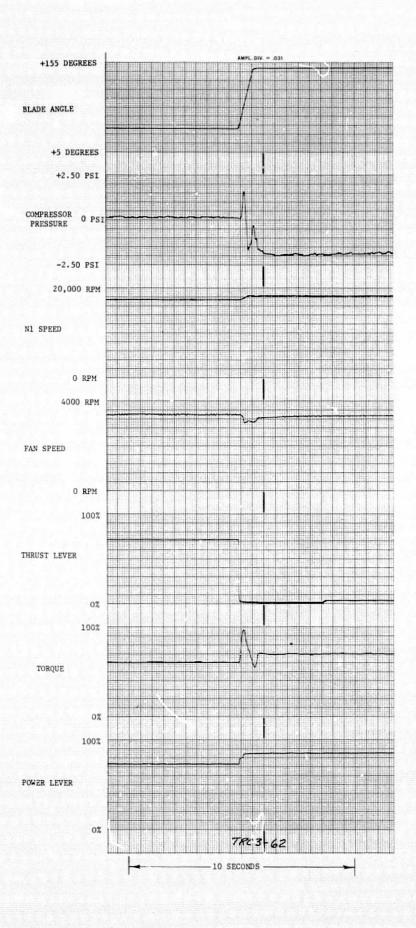


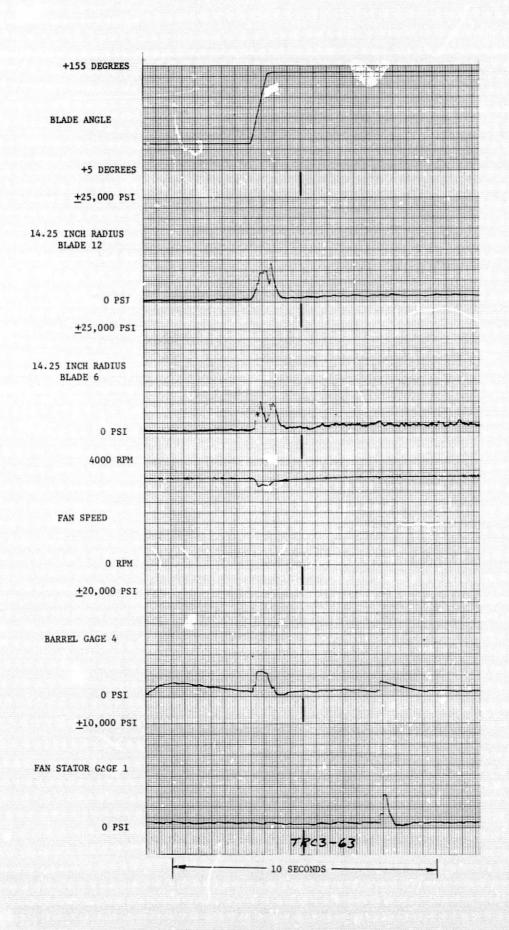




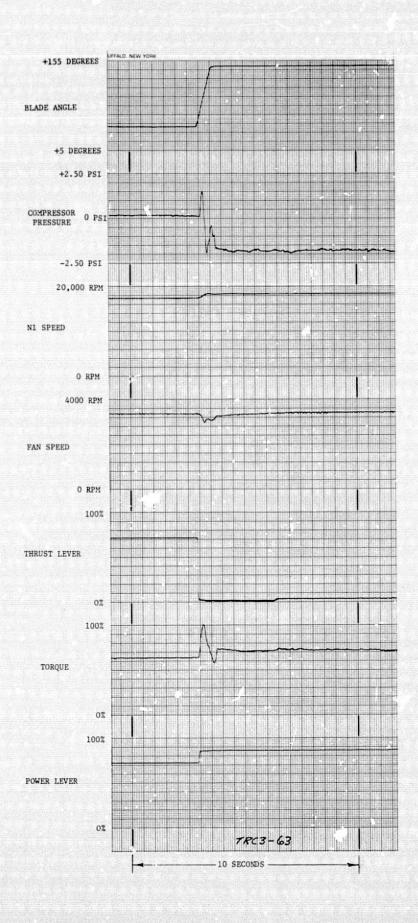


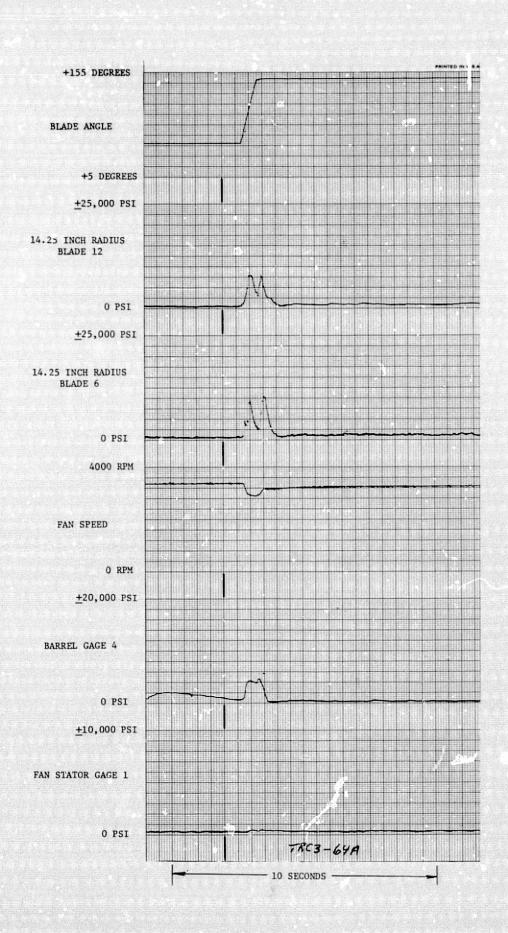


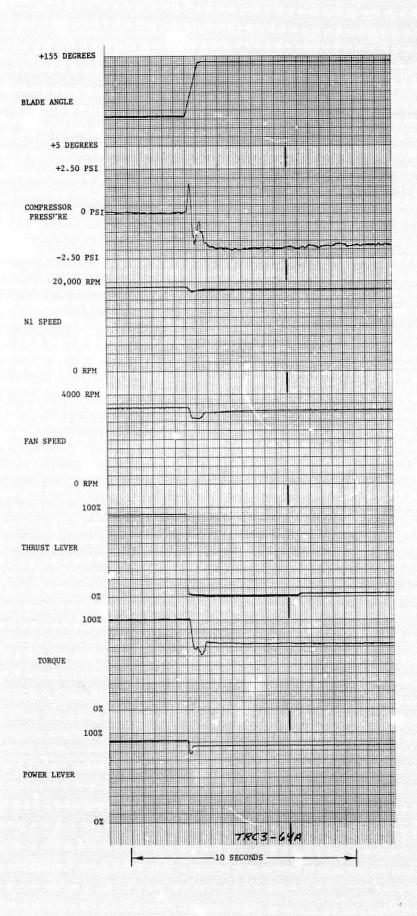


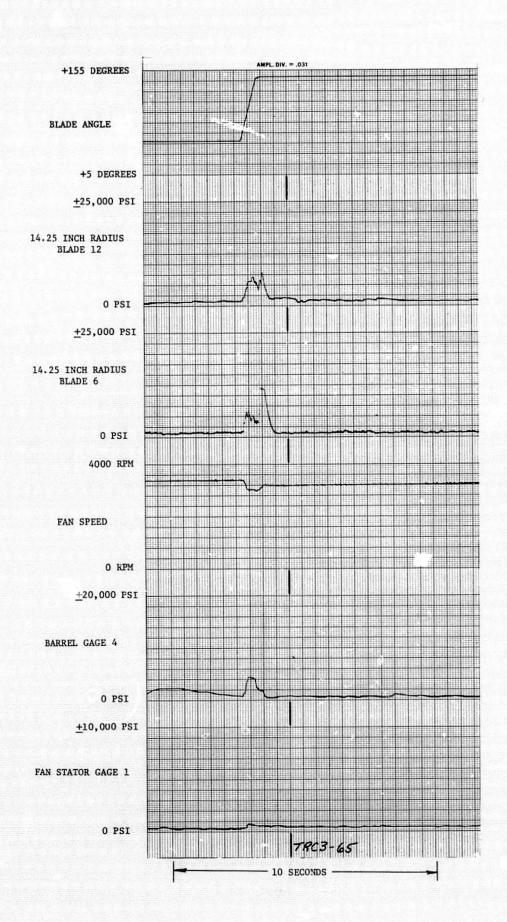


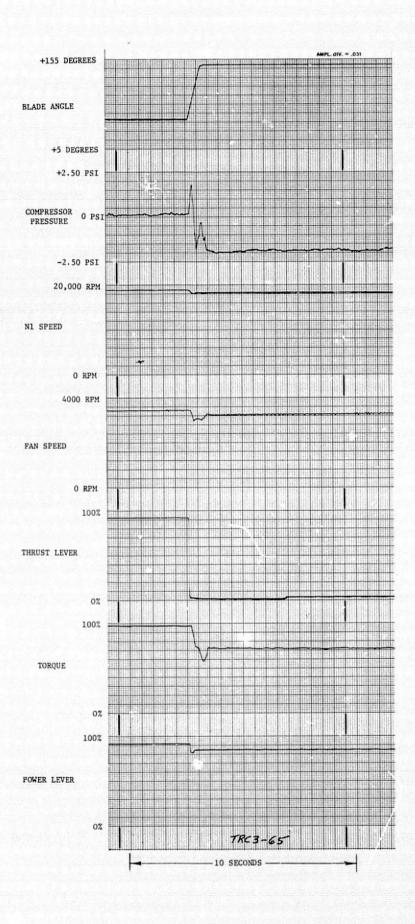
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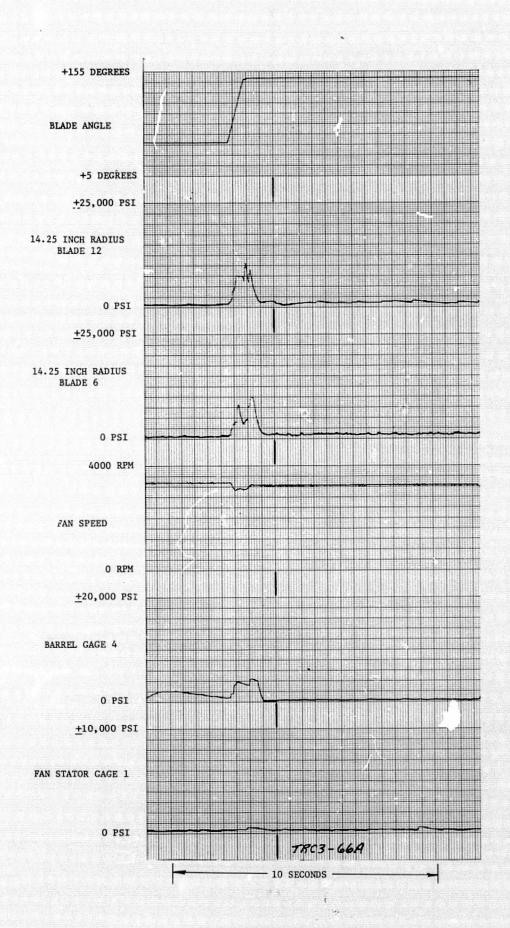


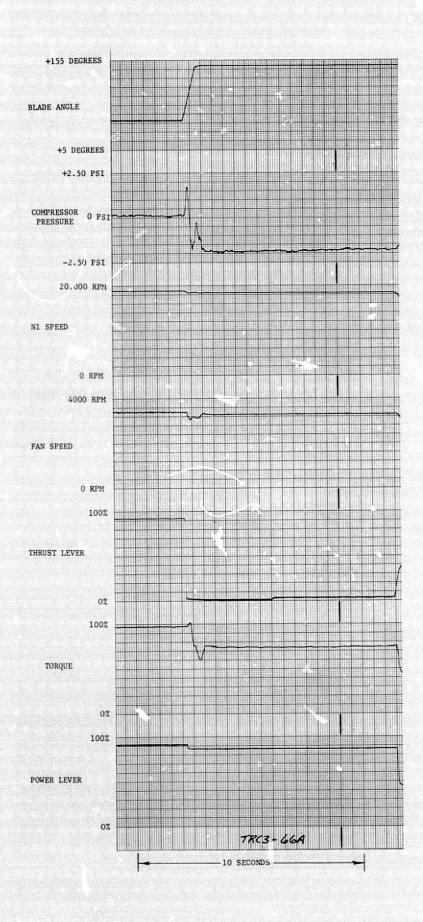


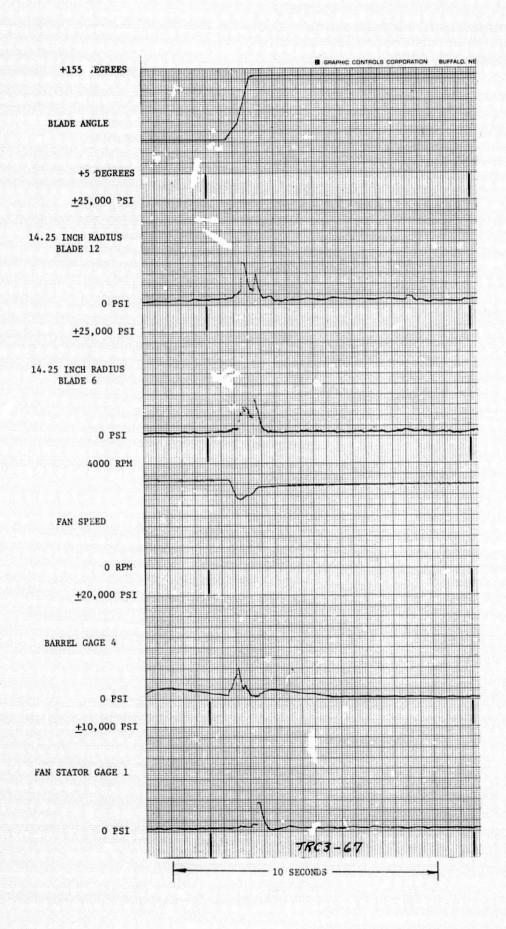


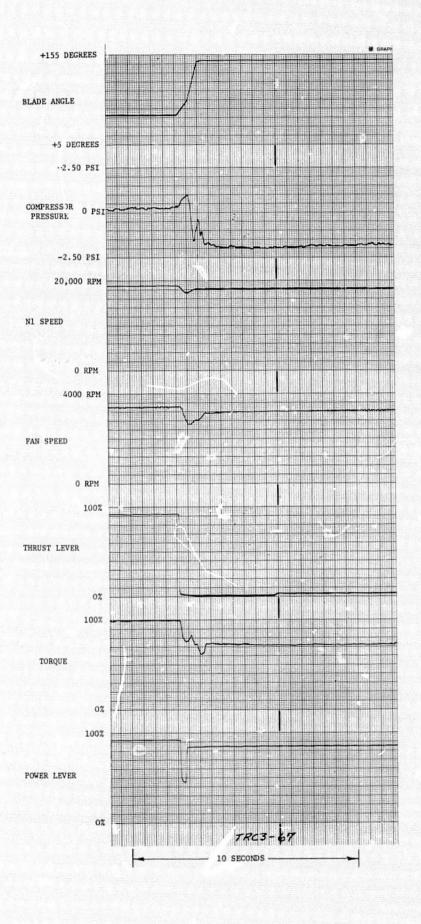


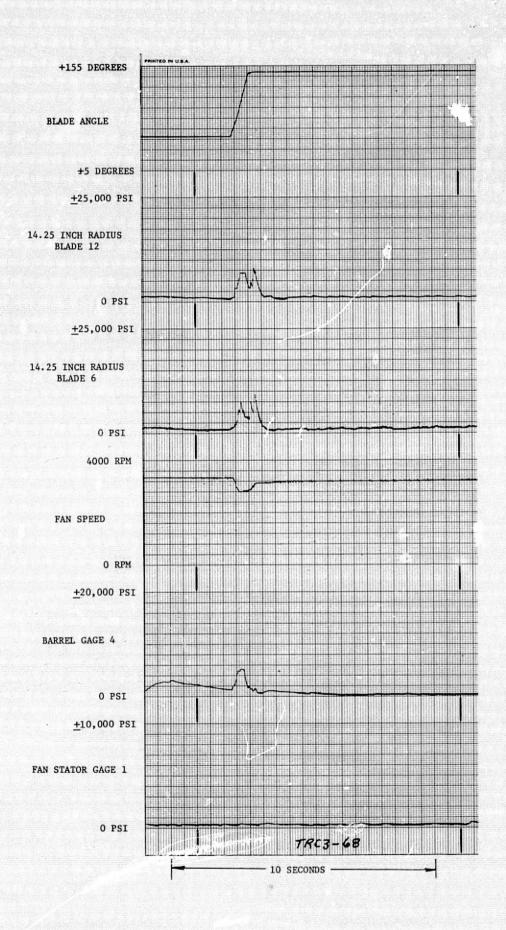


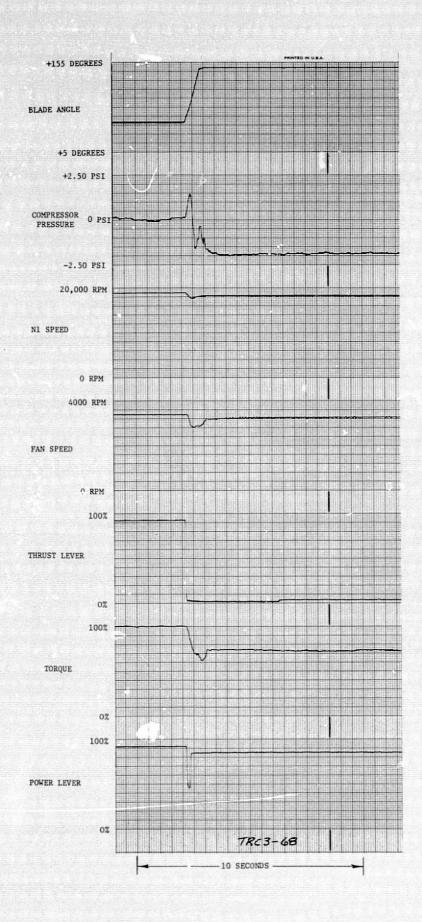


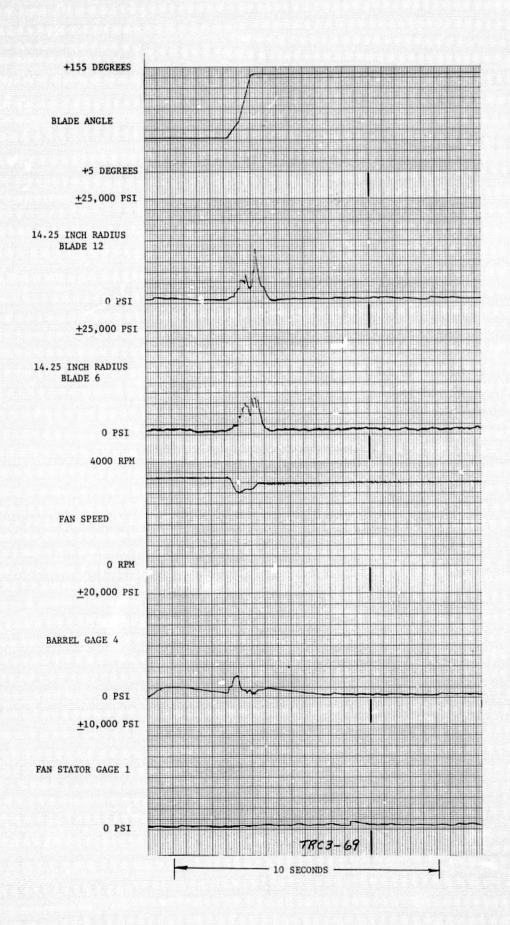


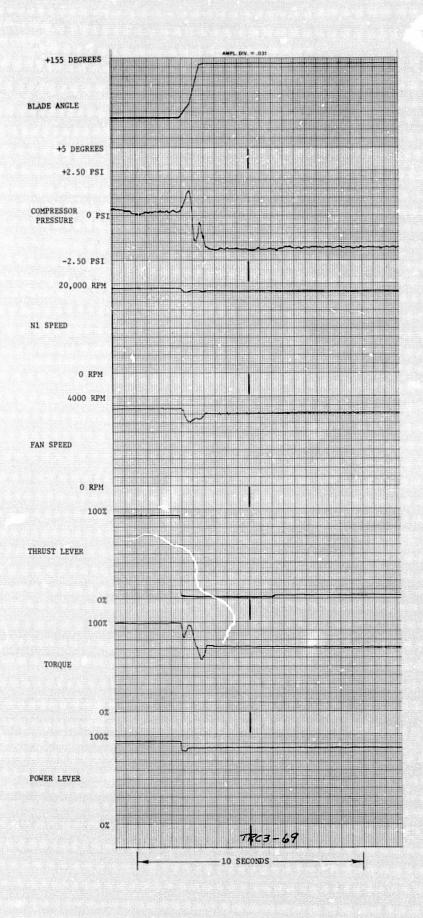


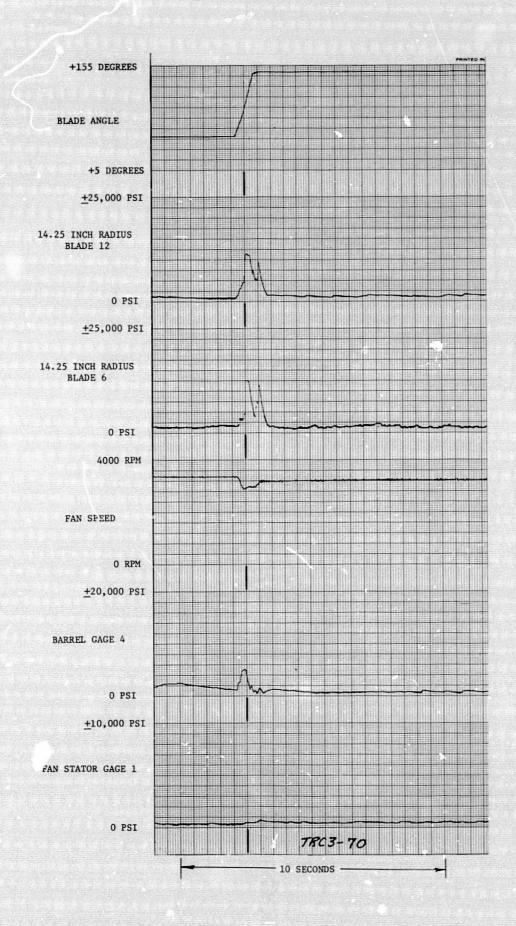


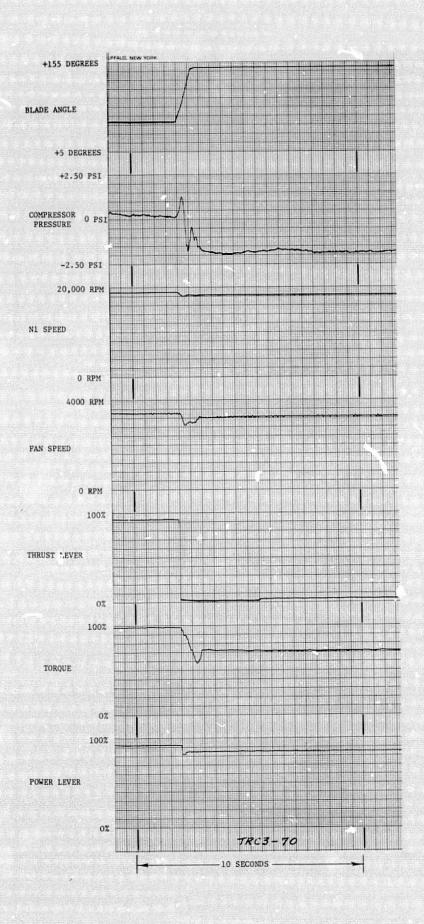


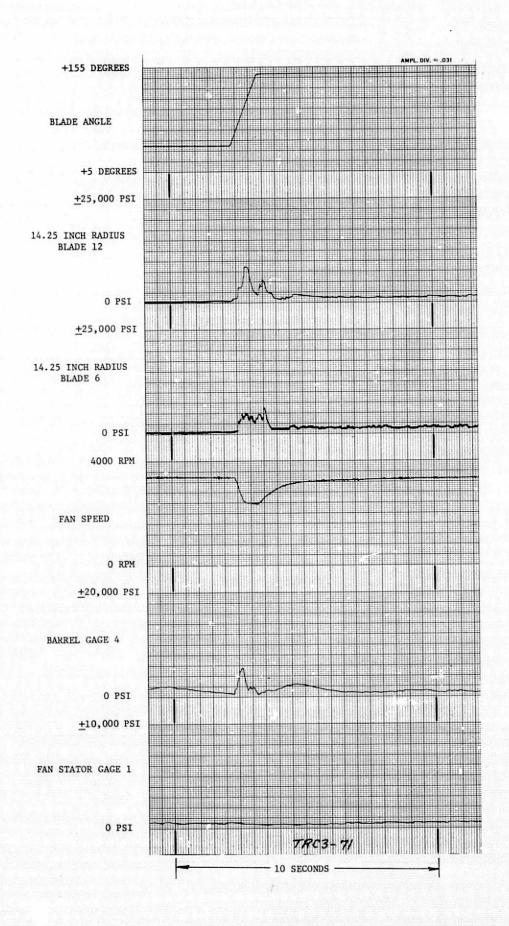


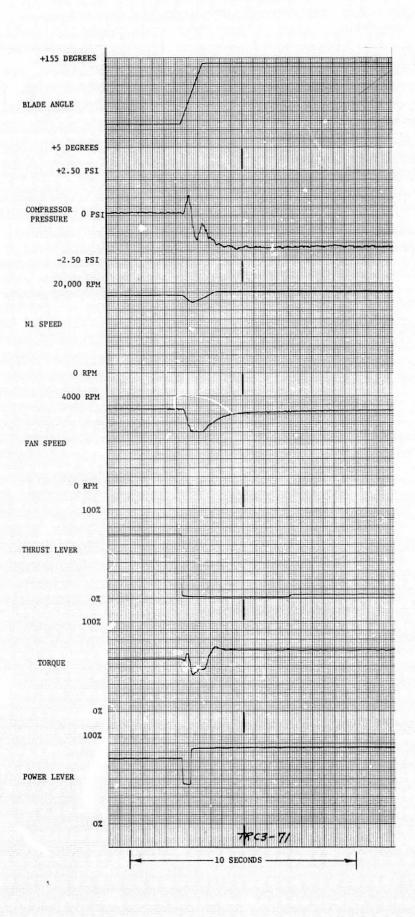


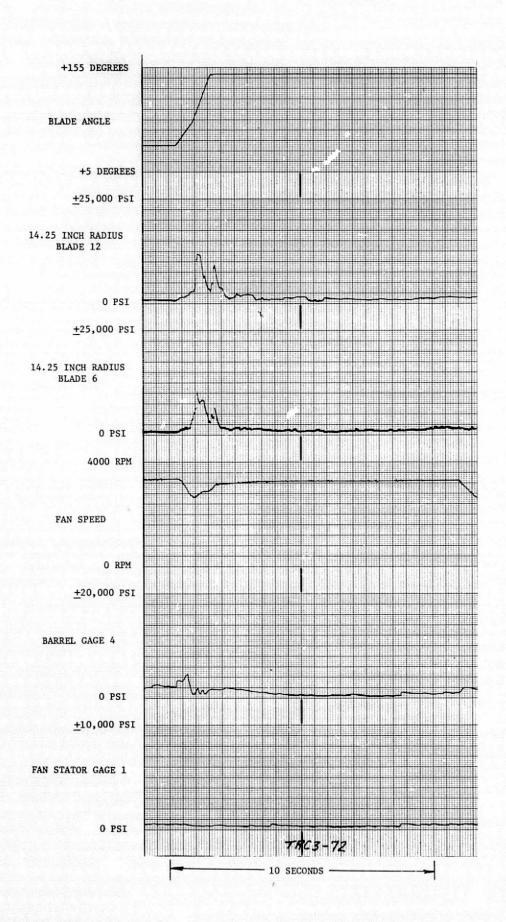


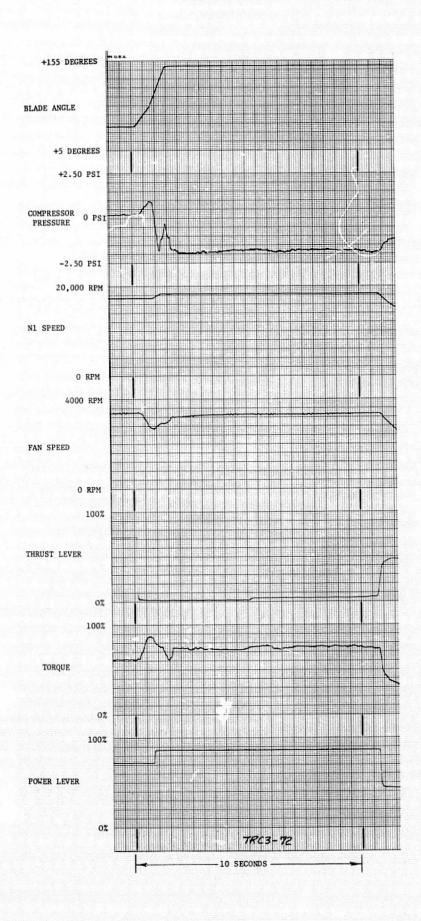


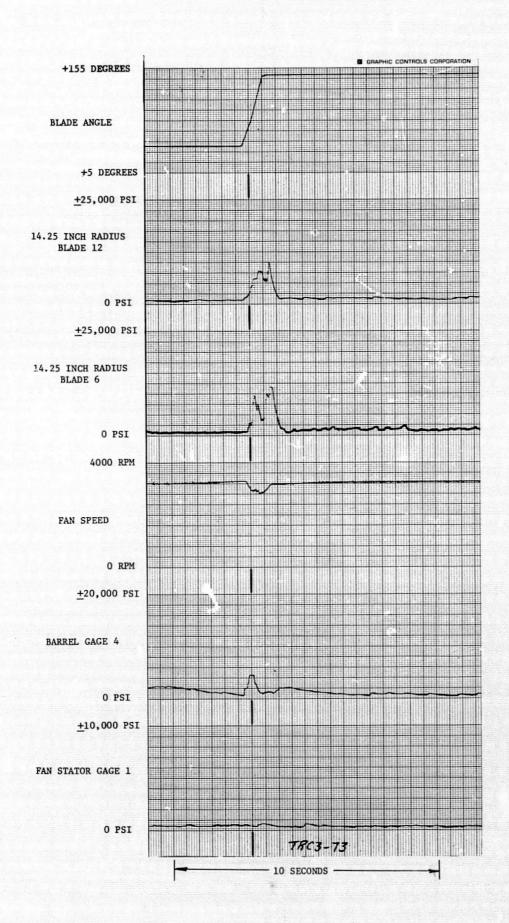


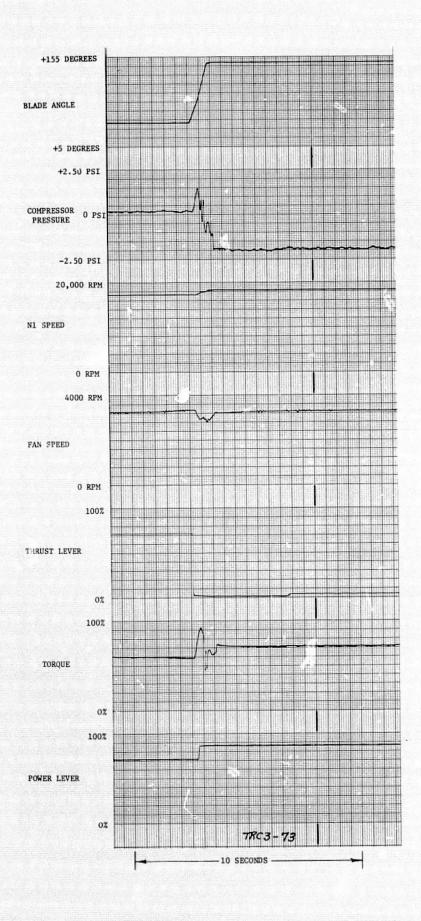


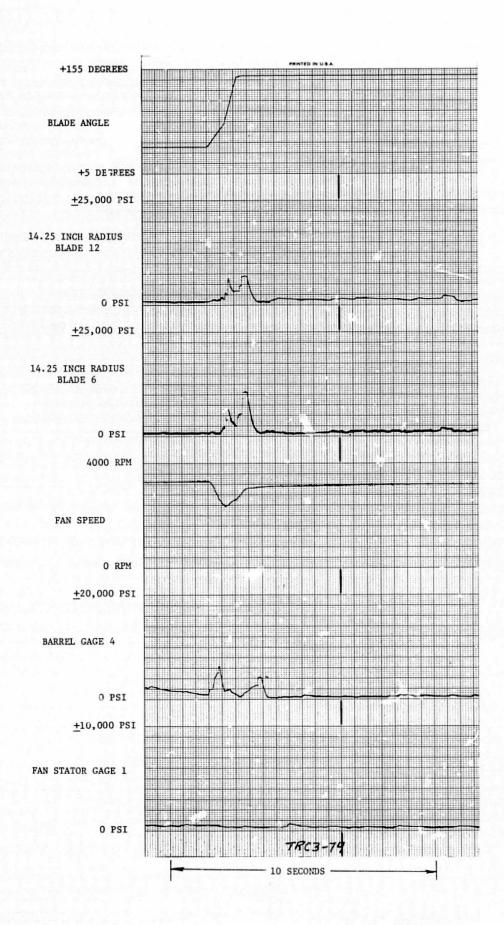


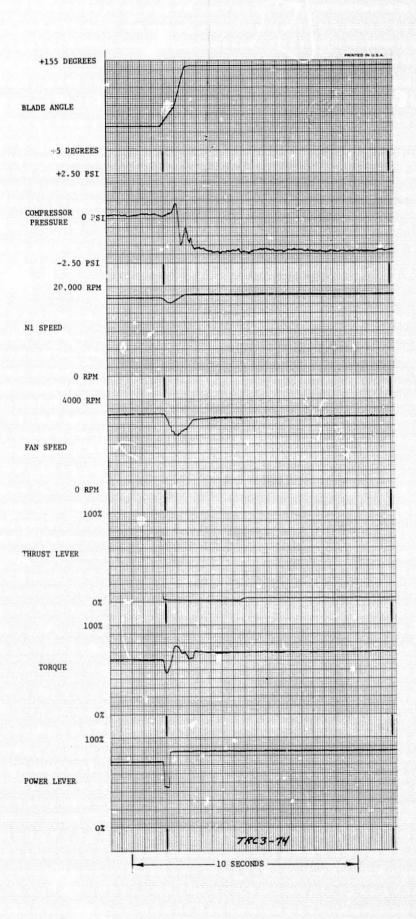


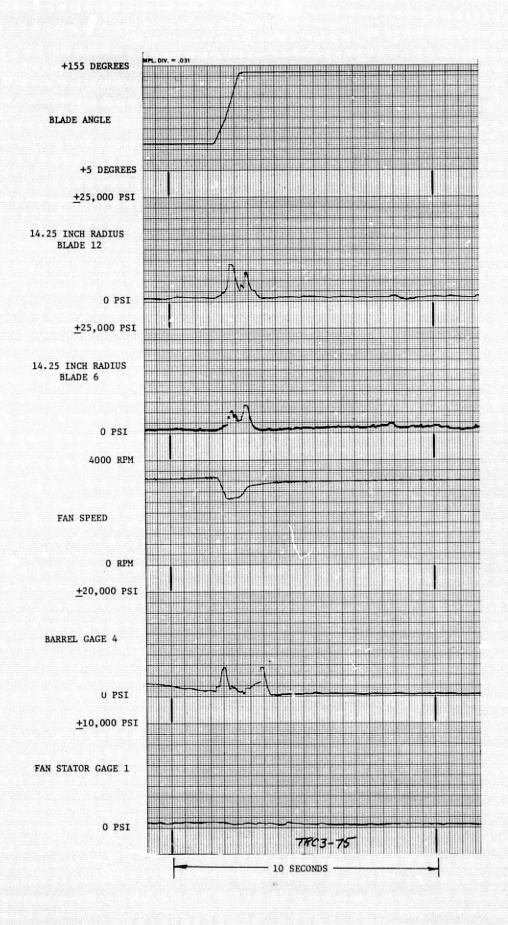


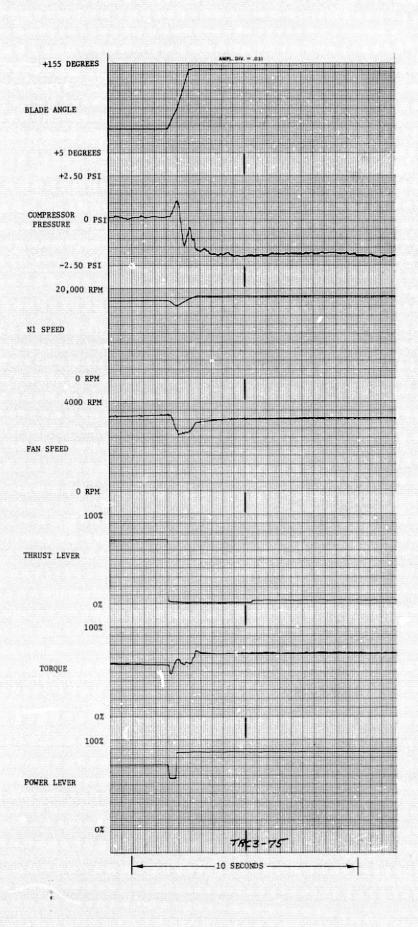


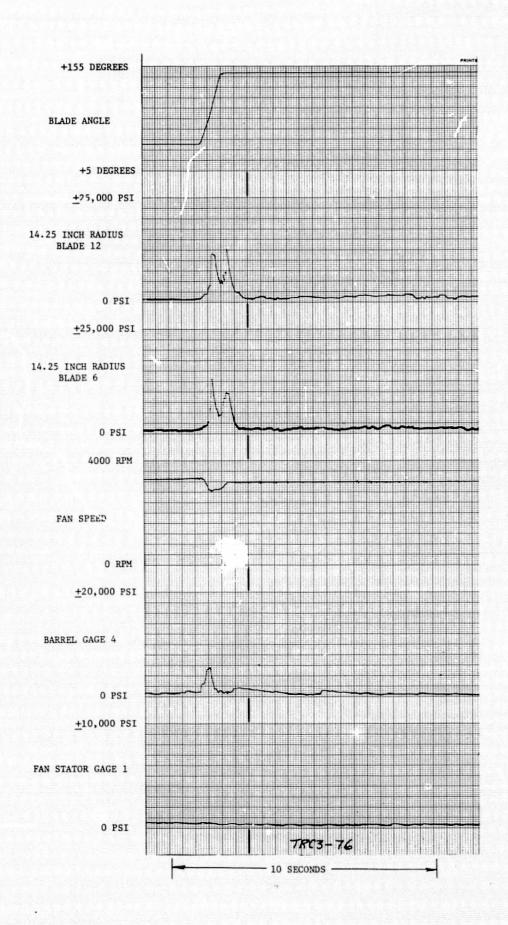


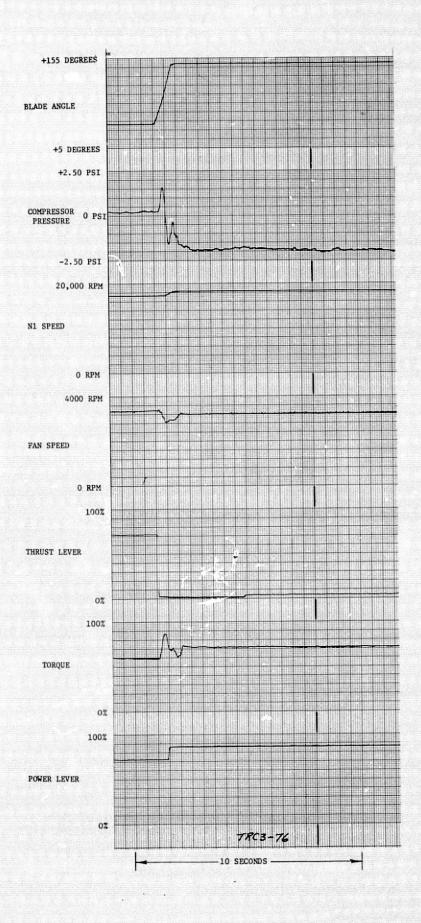


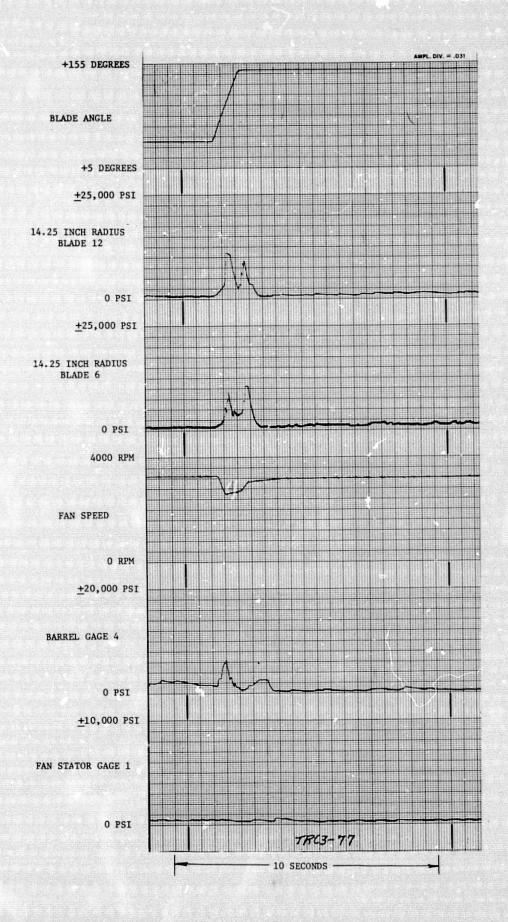


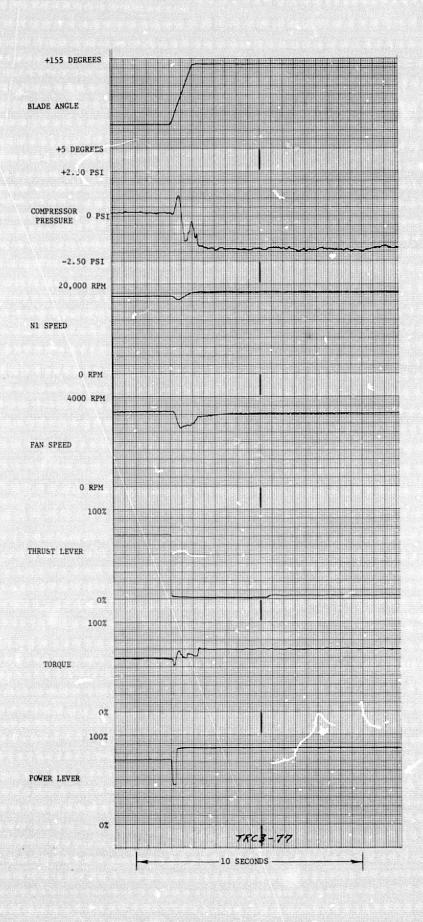


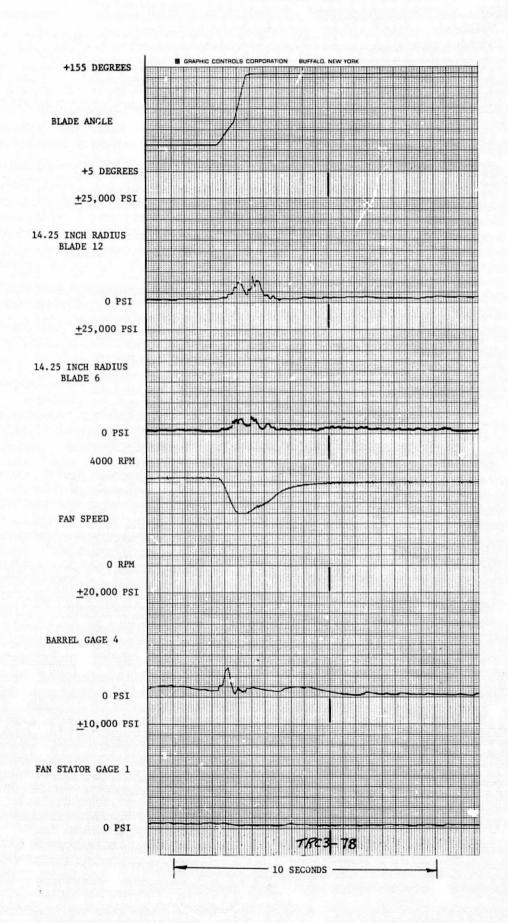


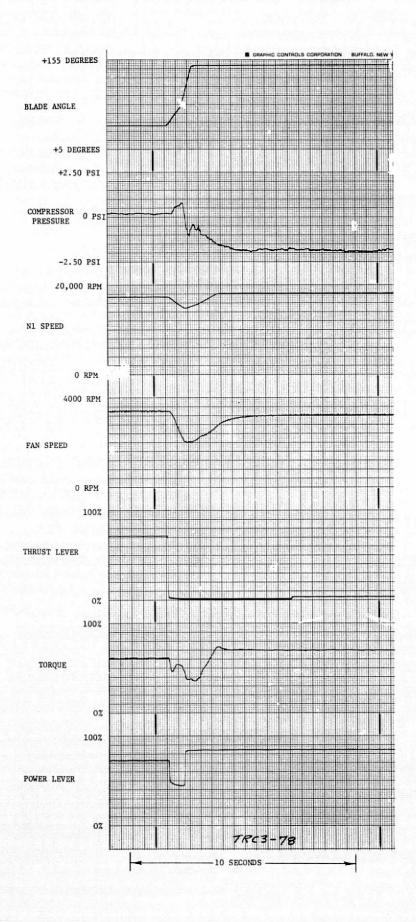


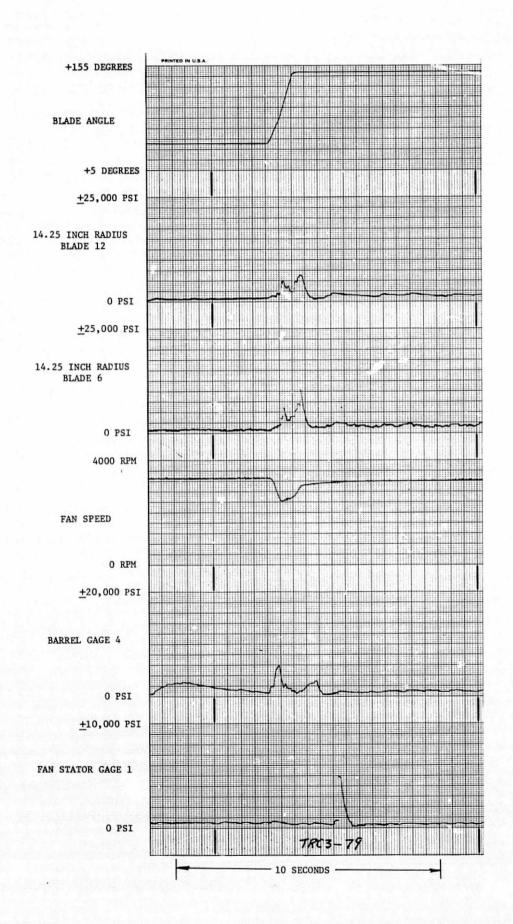


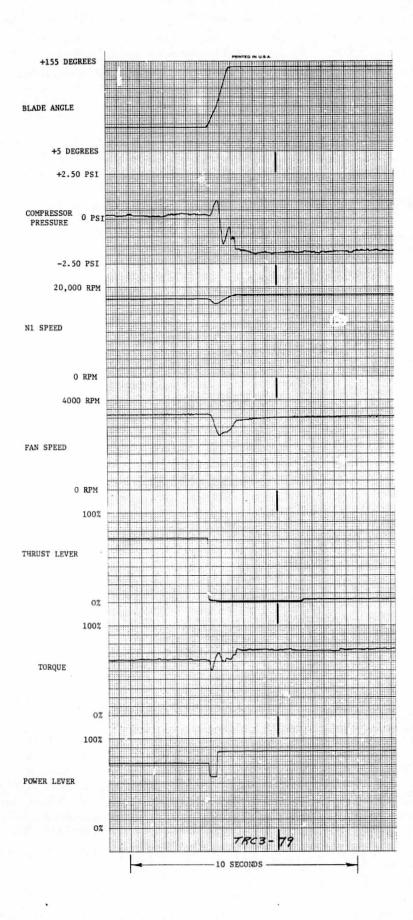


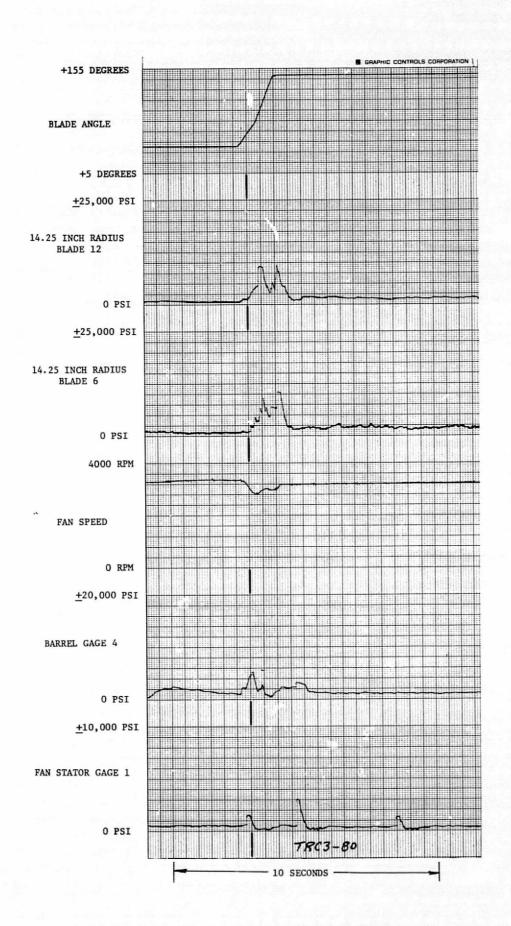


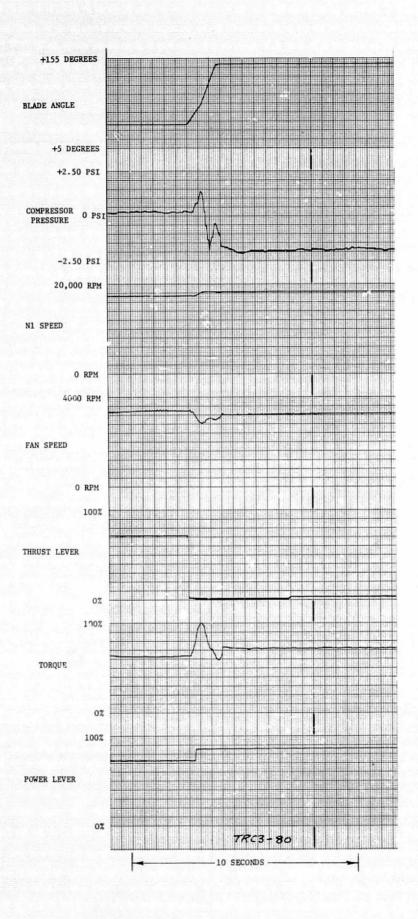






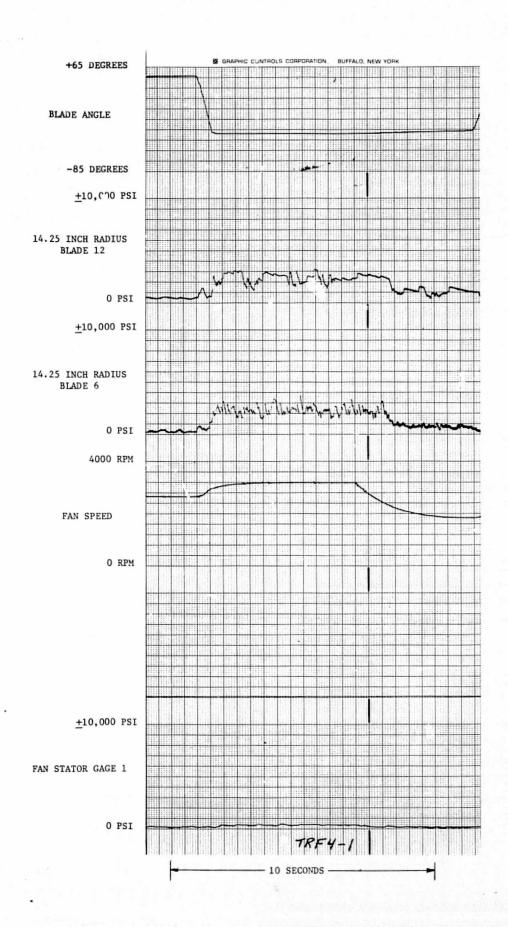


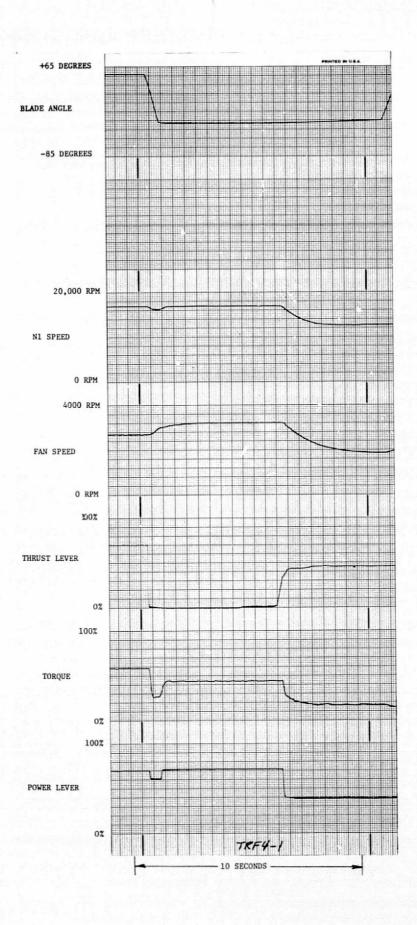


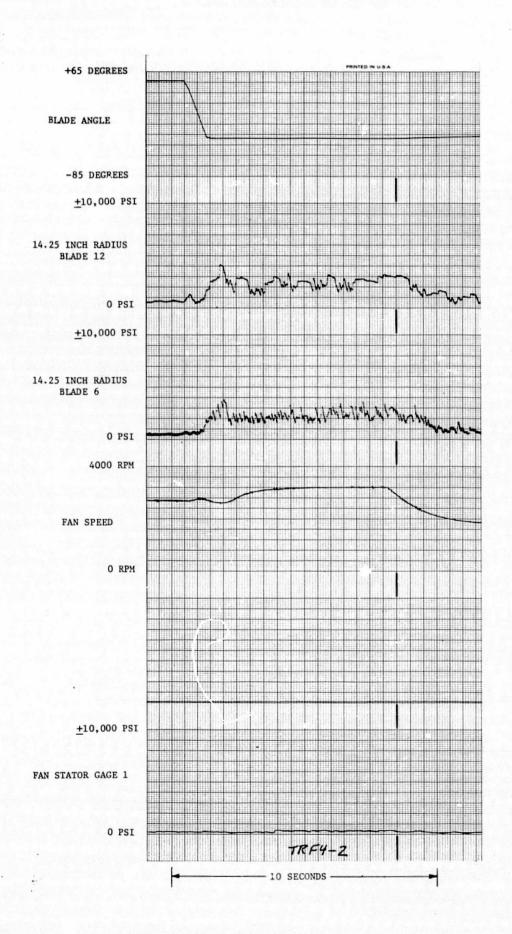


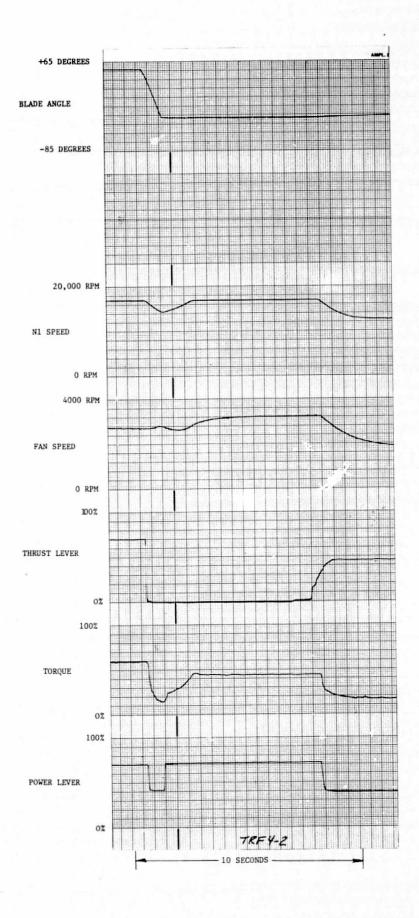
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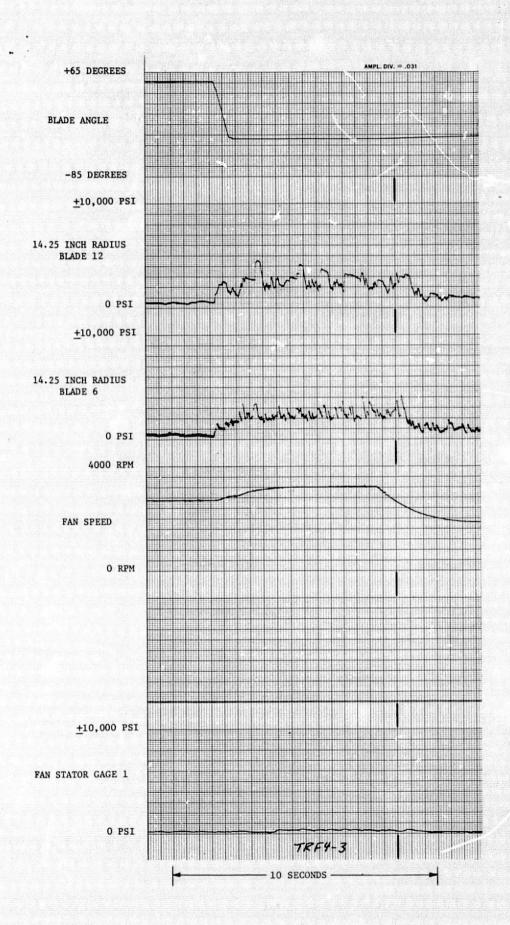
Reverse through Flat Pitch Transients - The following are Sanborn recordings of various parameters taped during the performance of the reverse through flat pitch (TRF) at the Hilltop facility at Hamilton Standard.



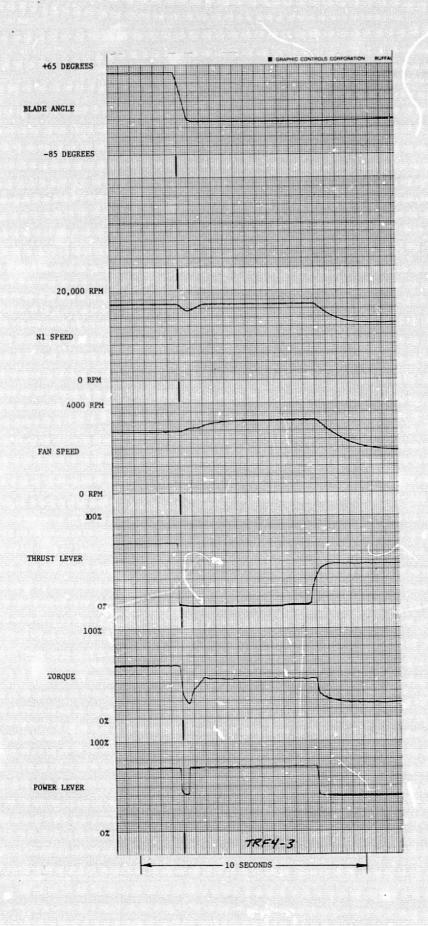


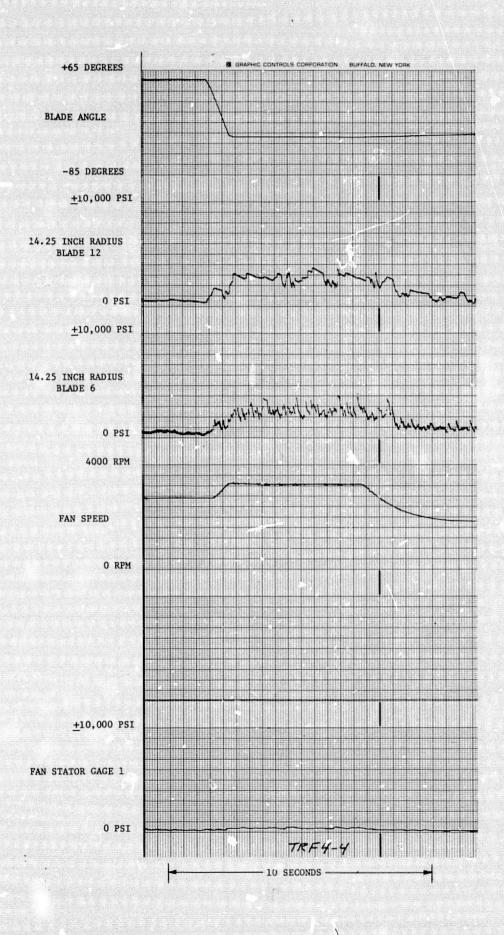


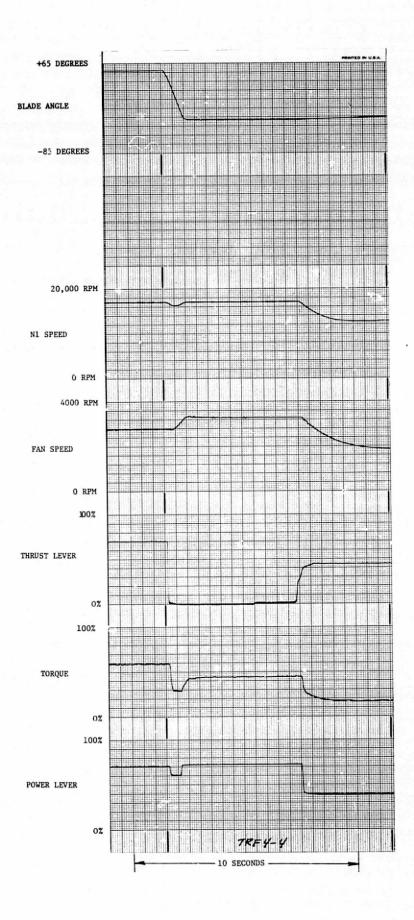


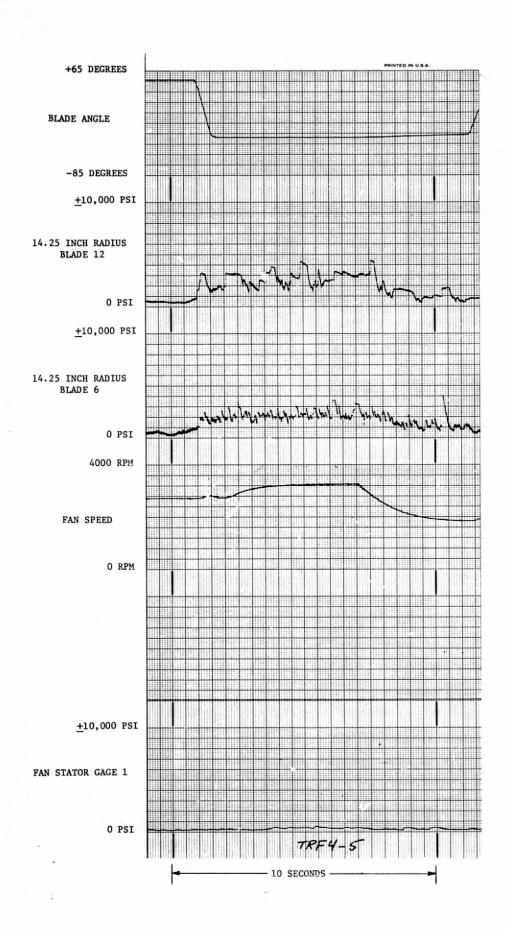


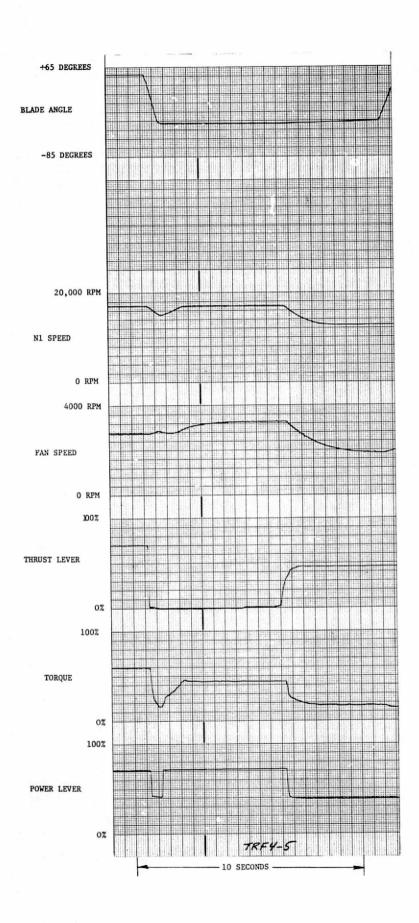


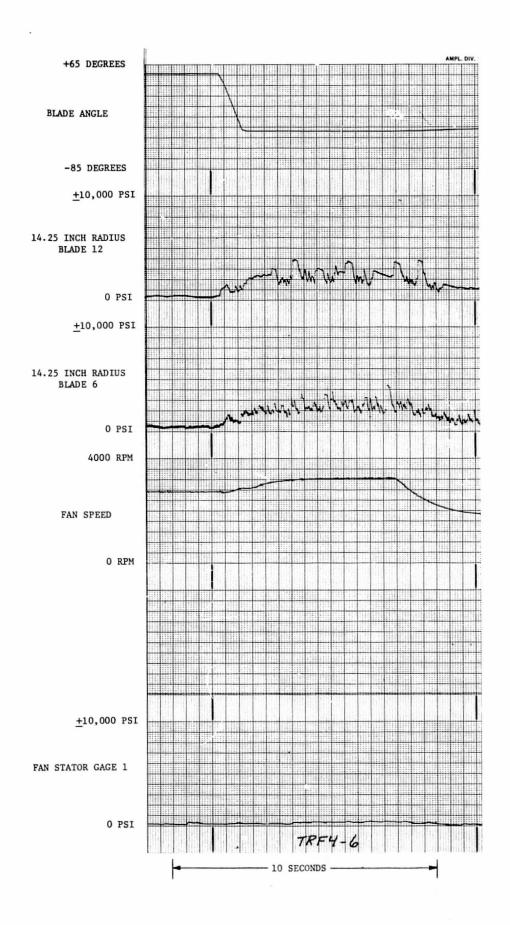


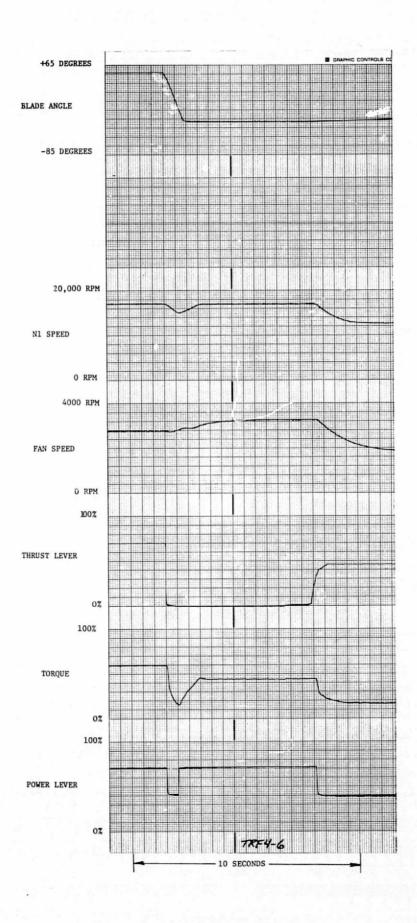


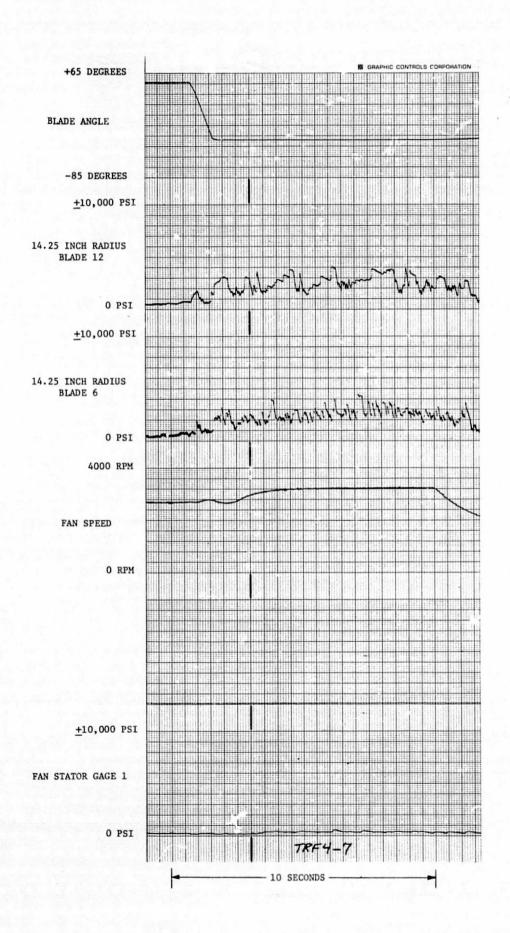


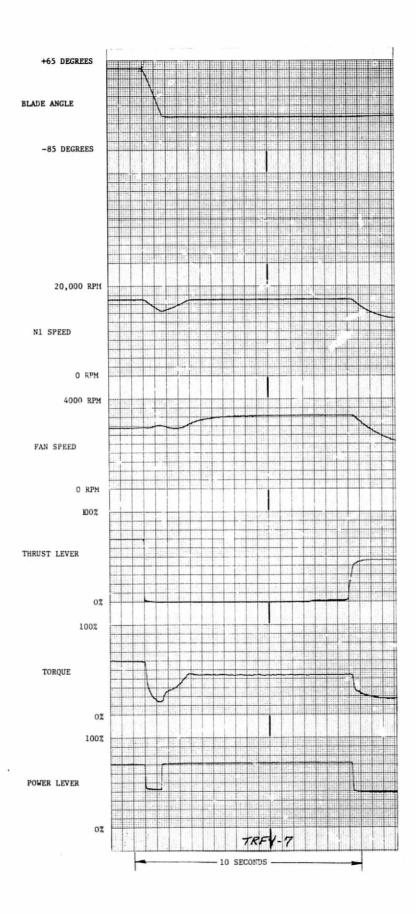


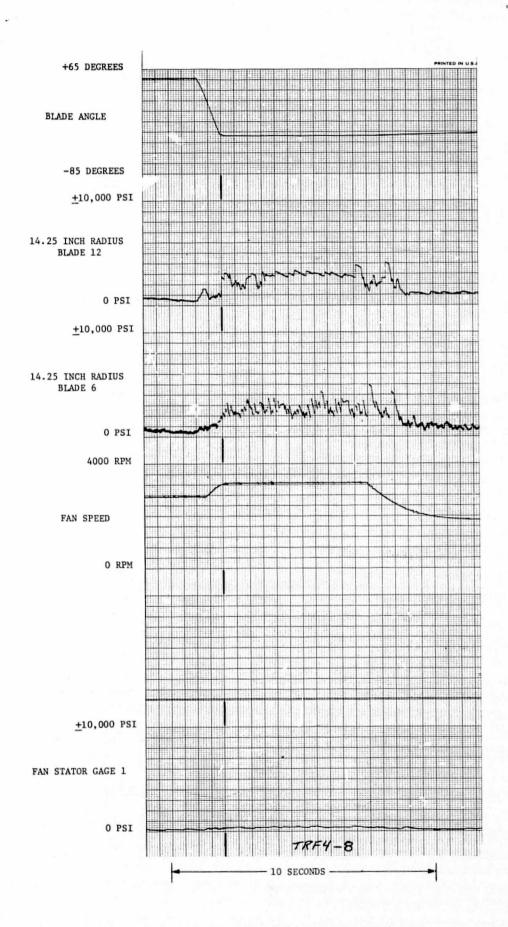




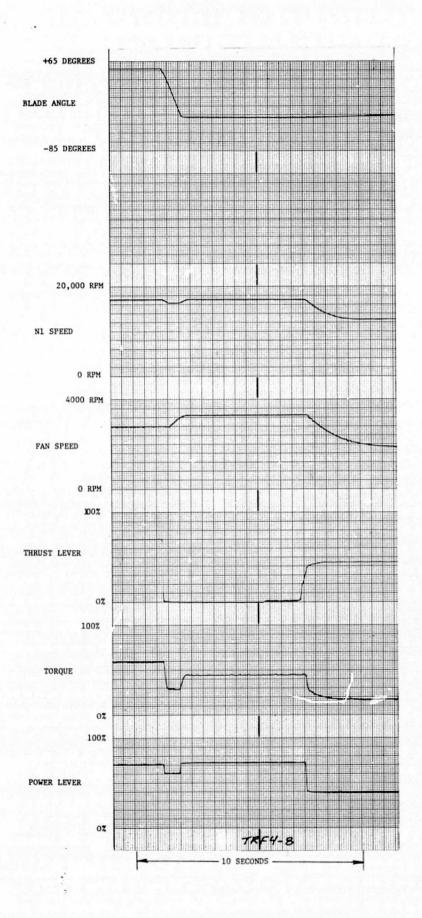


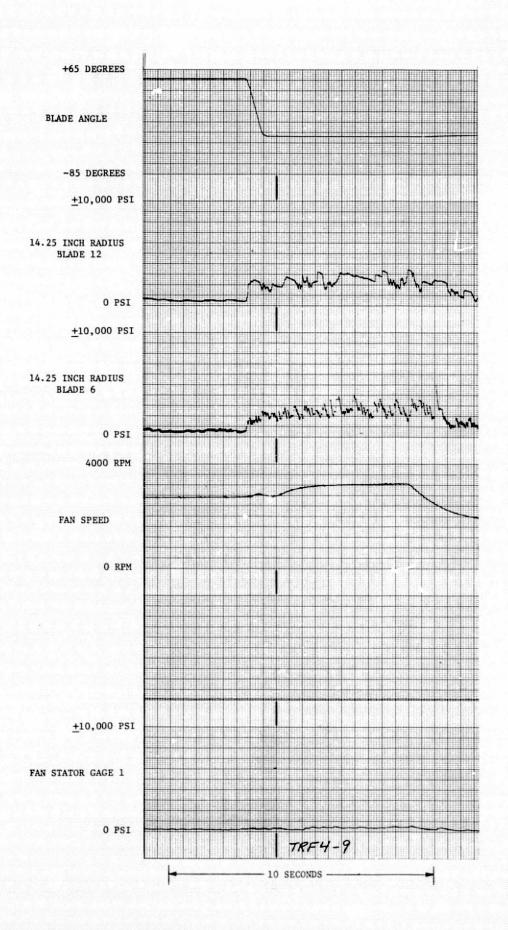


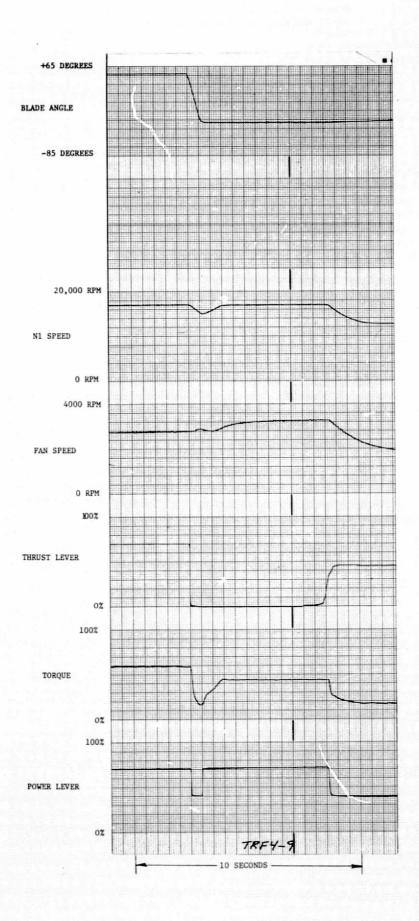


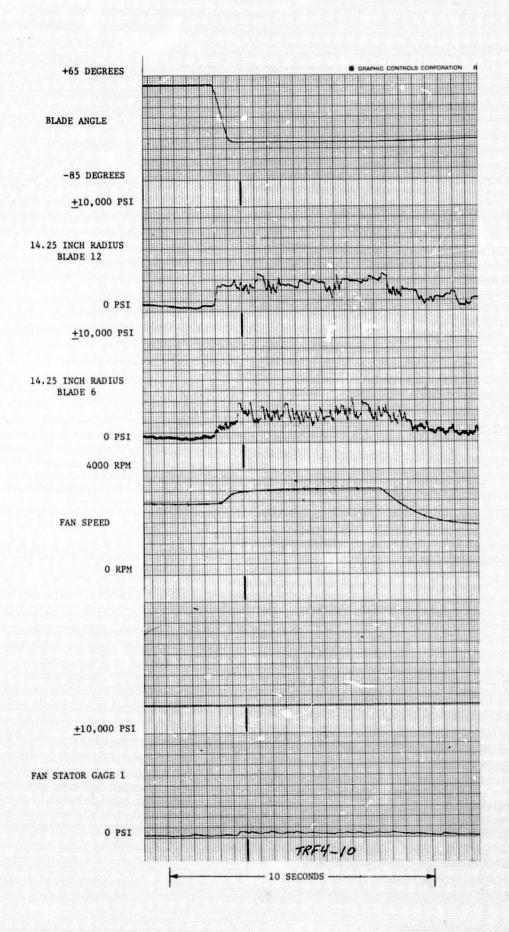


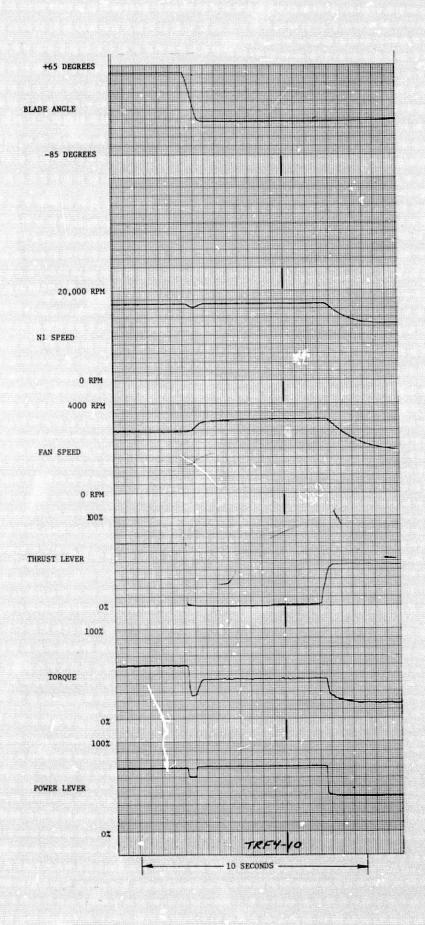


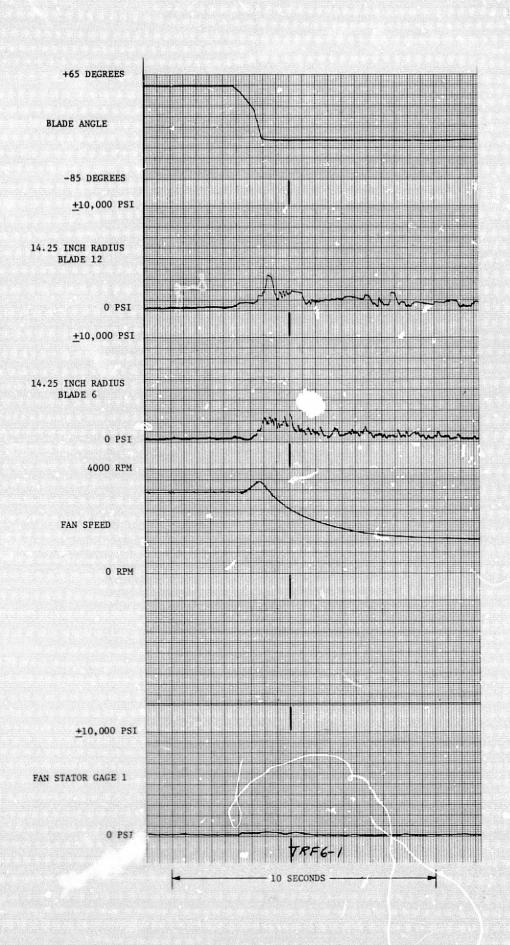


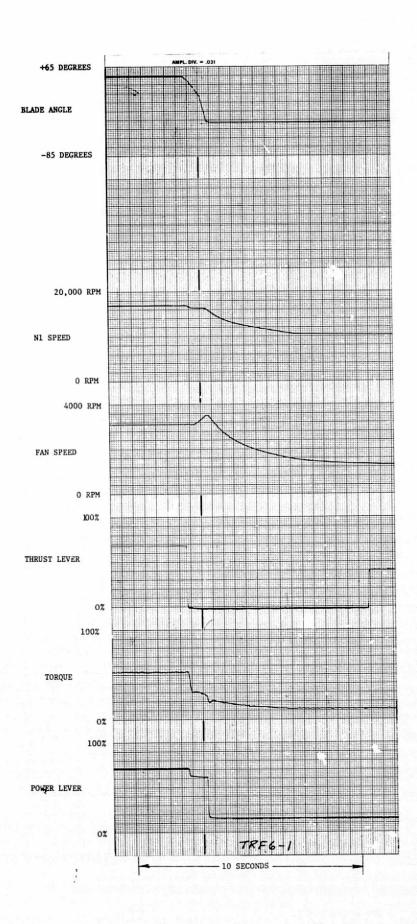


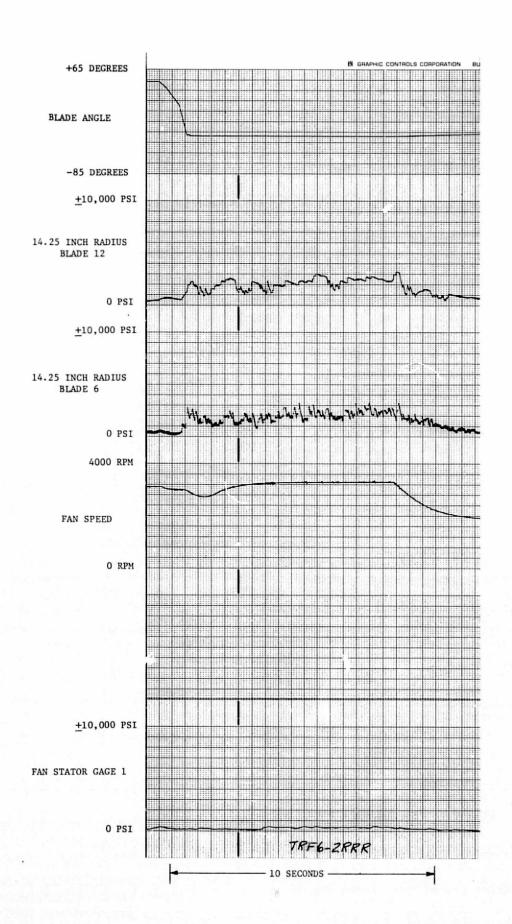


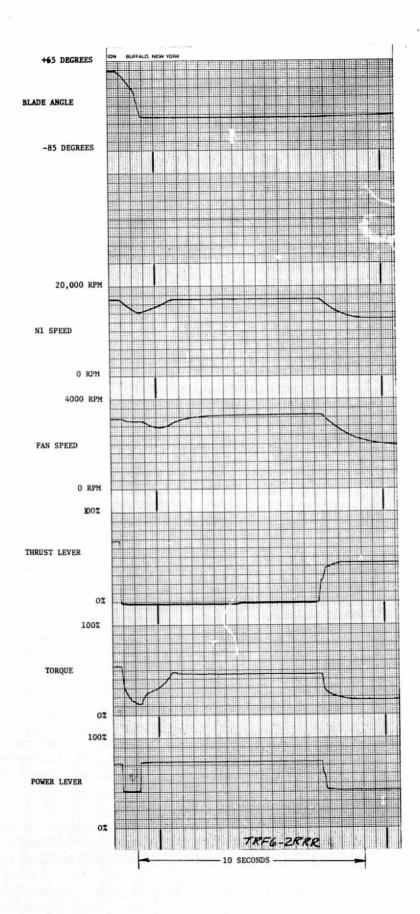


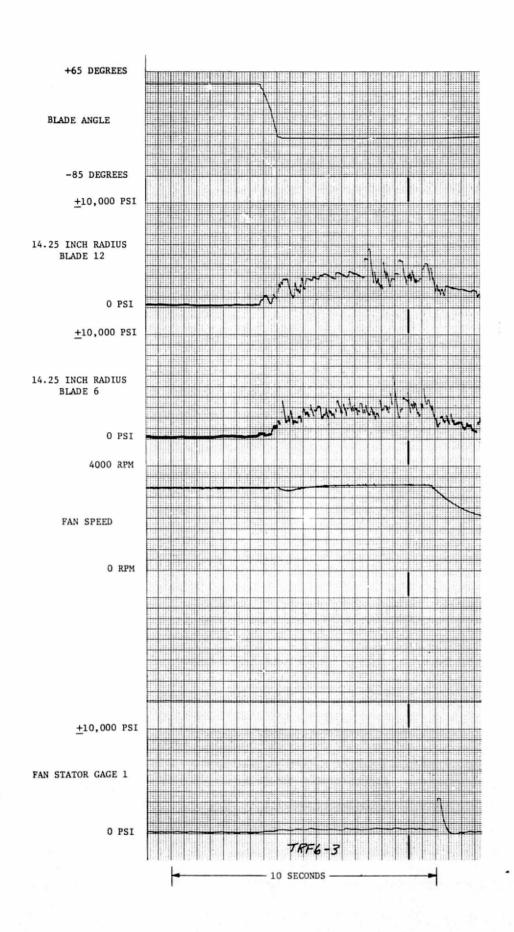


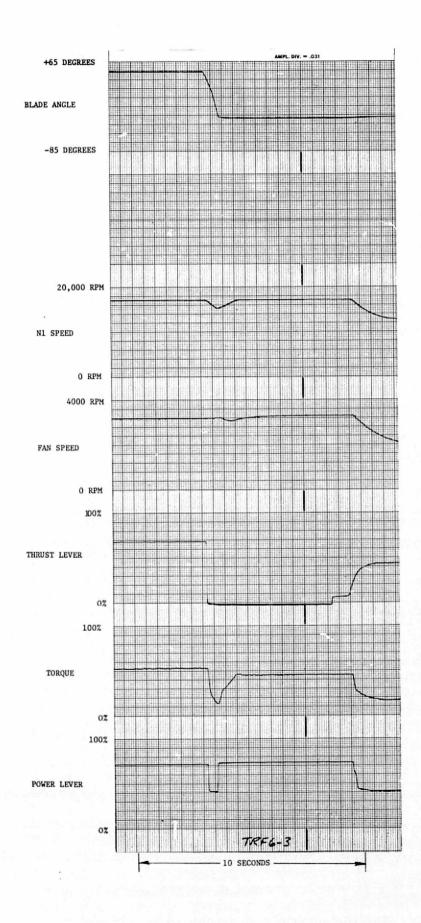


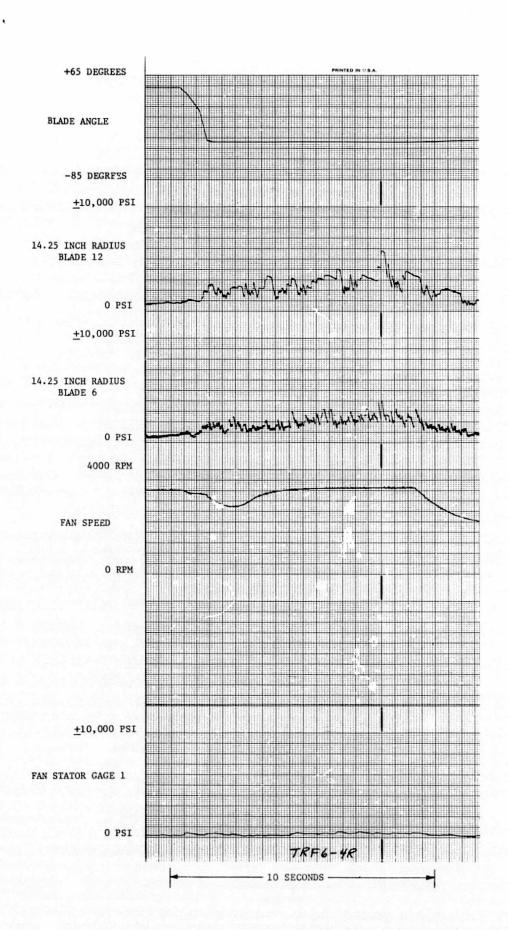


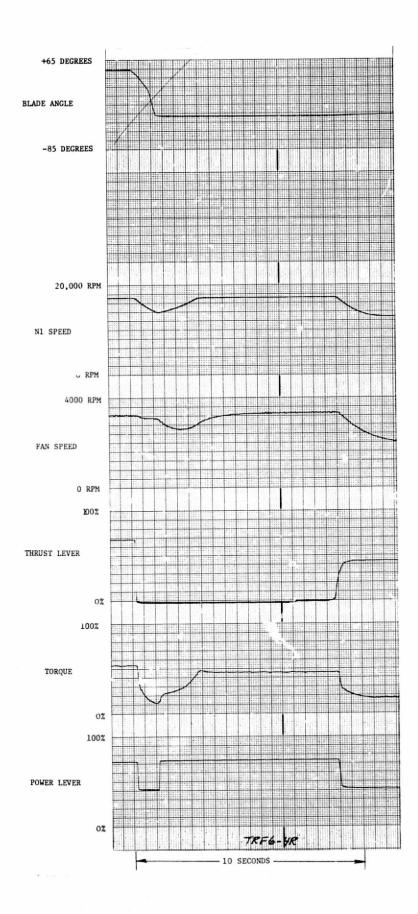


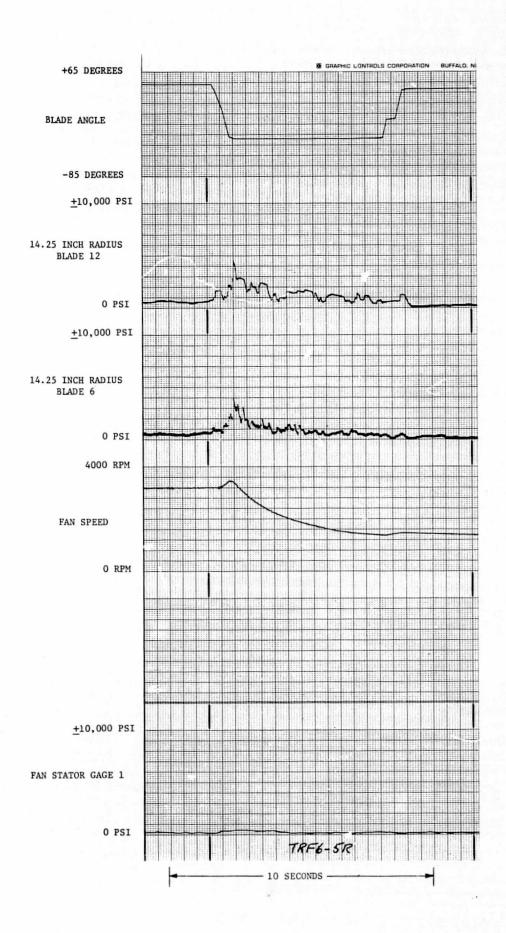


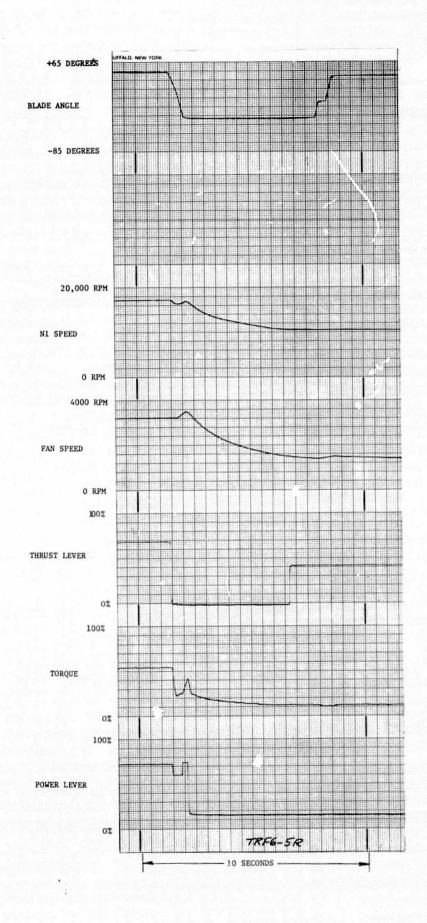


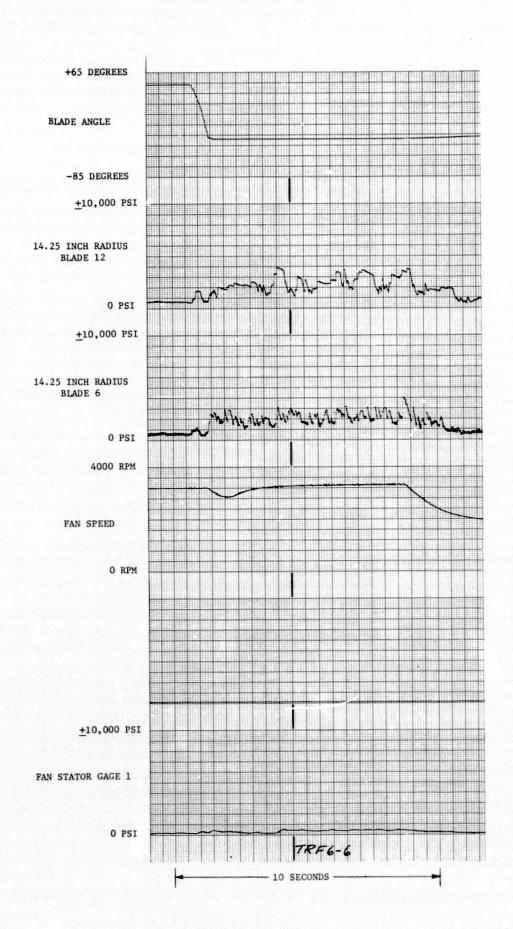


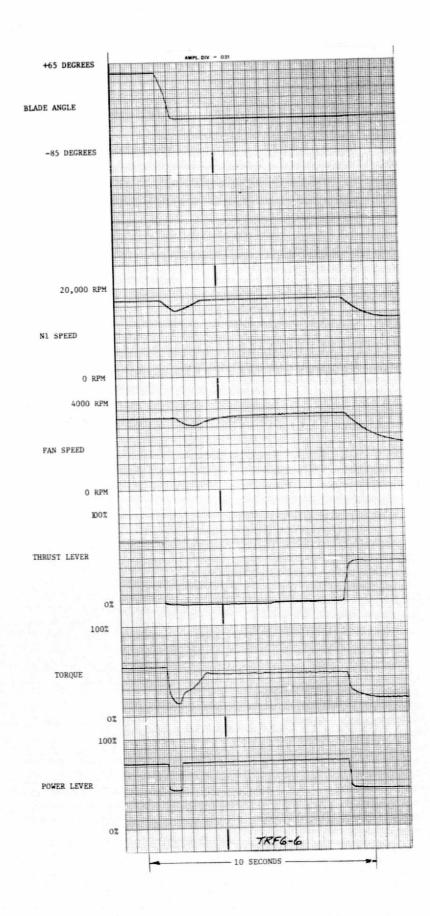


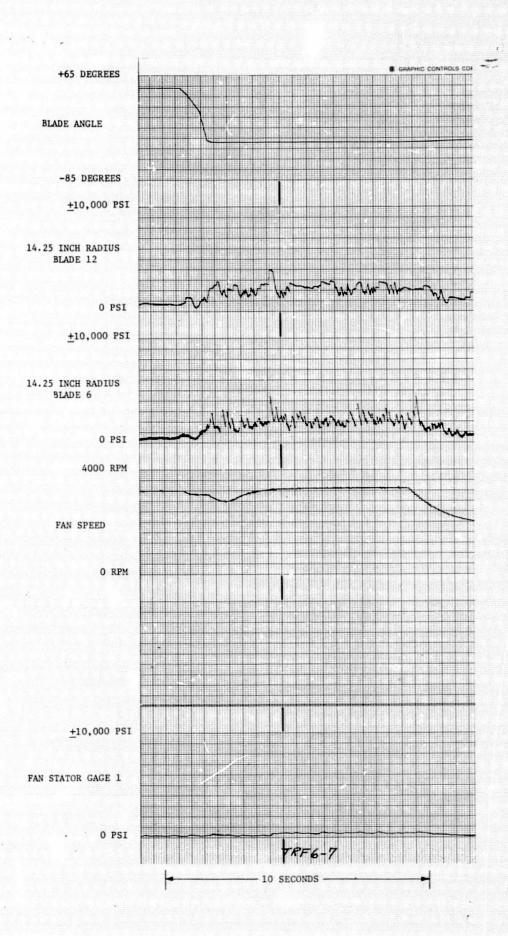


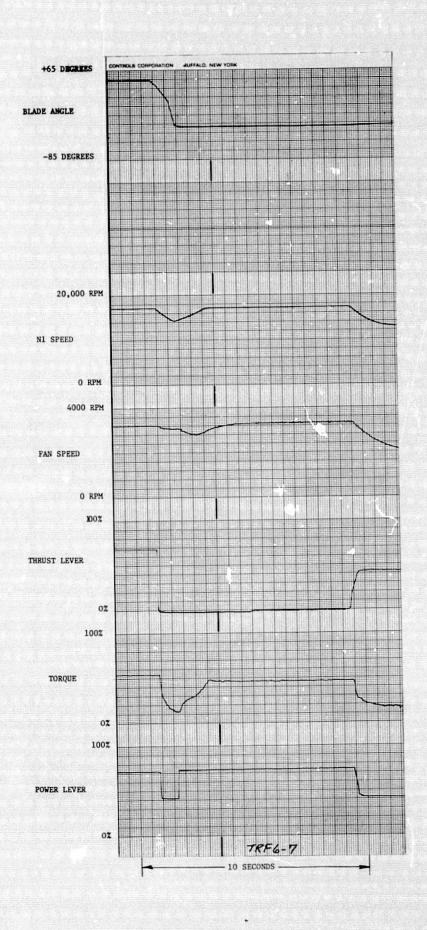


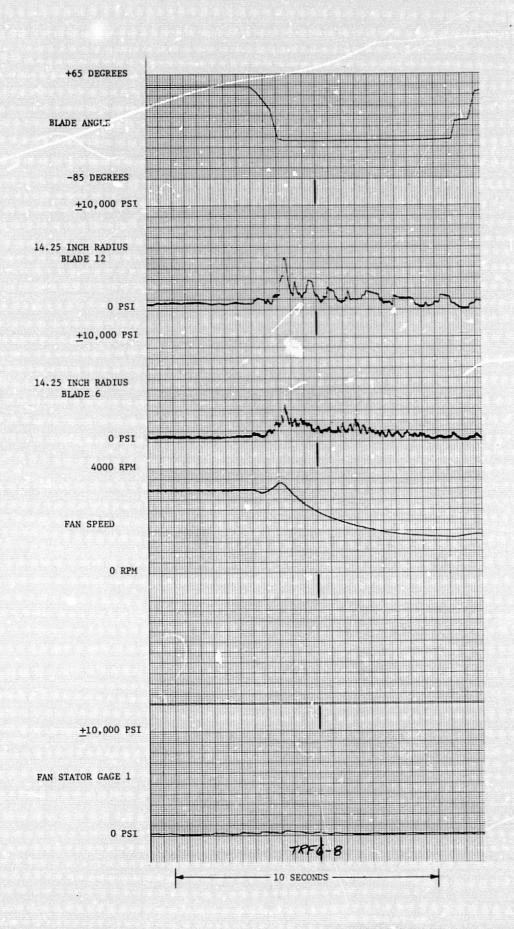


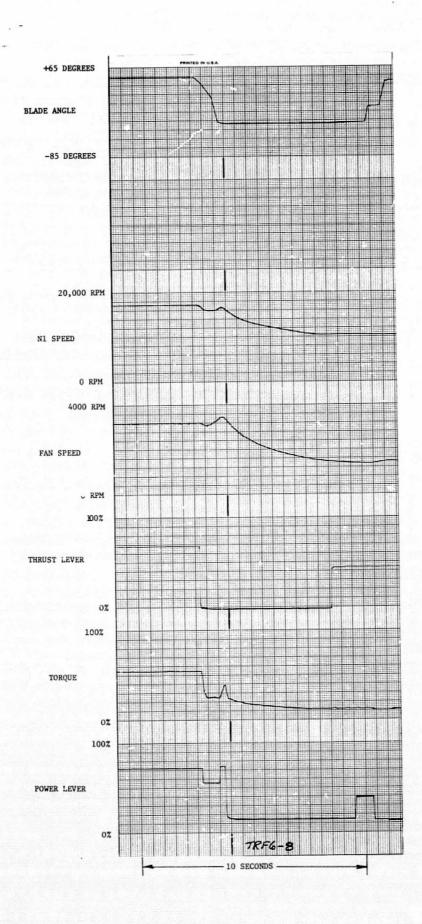


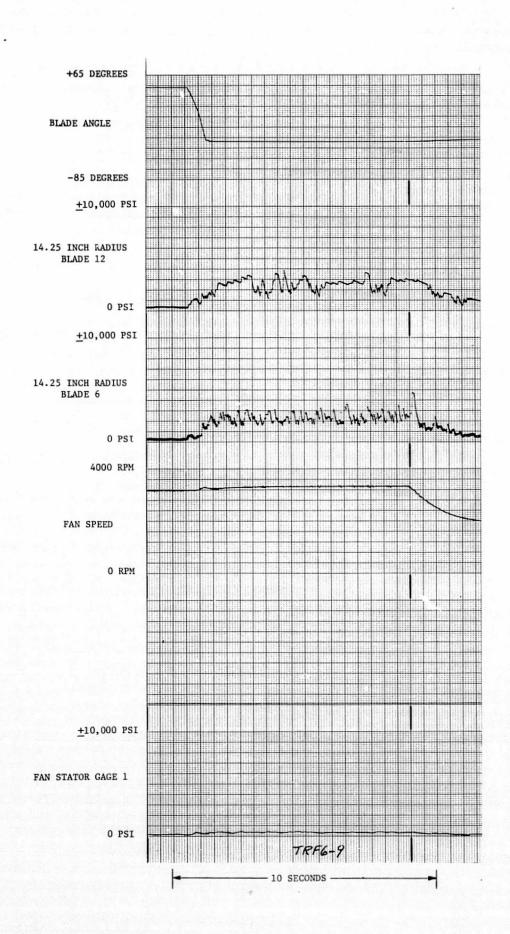


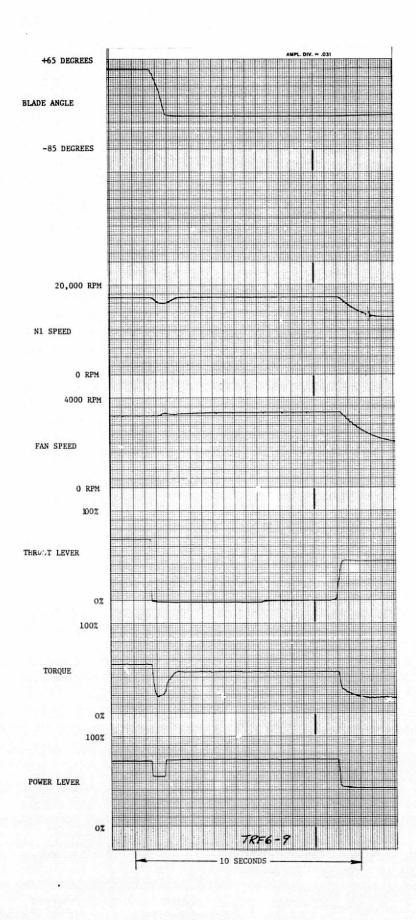


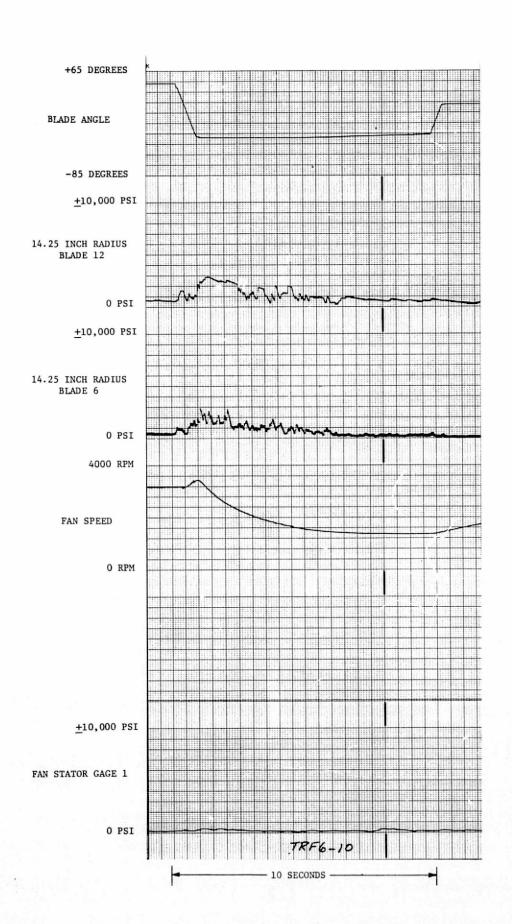


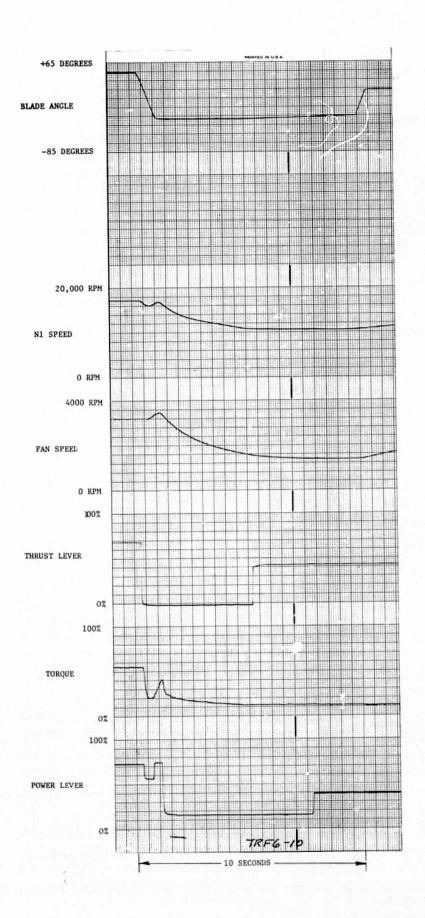


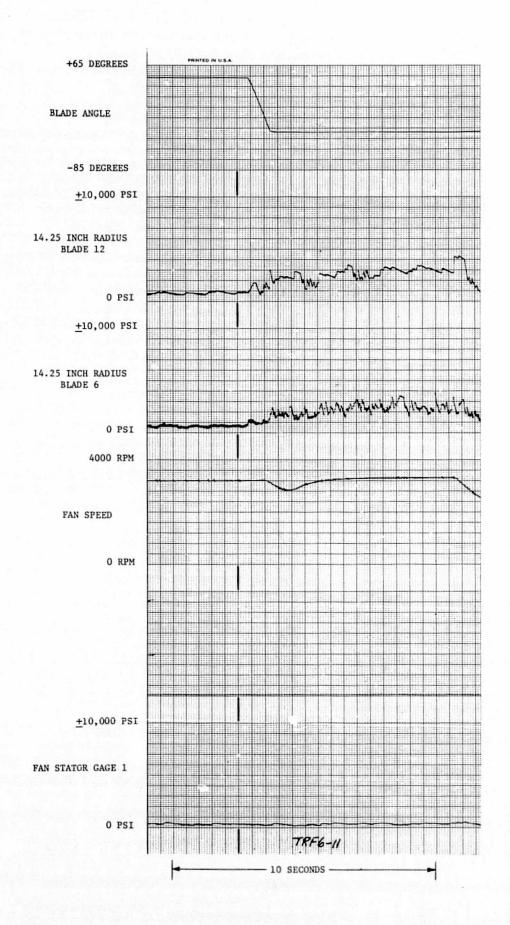


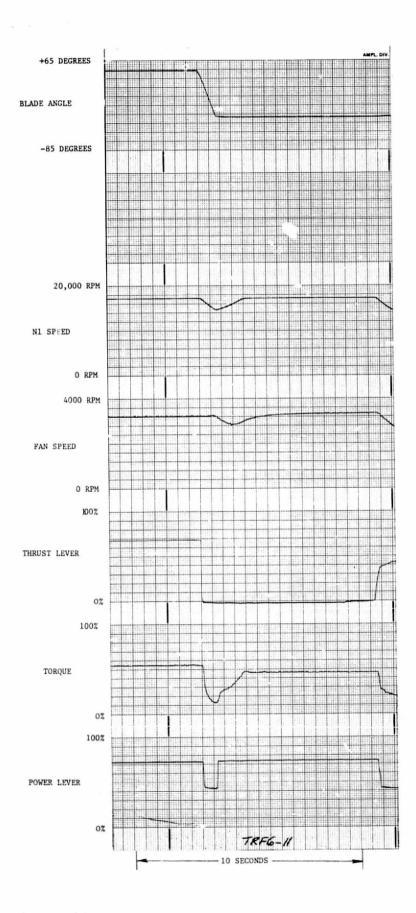


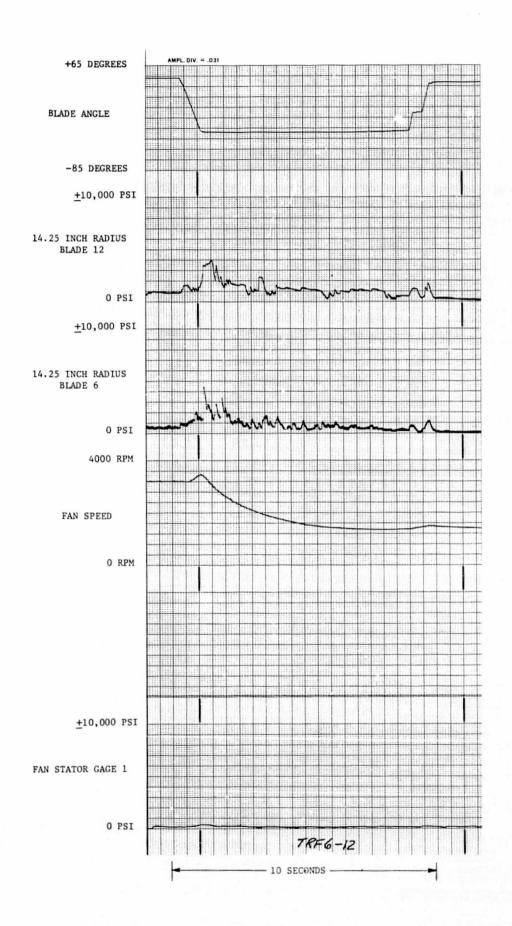


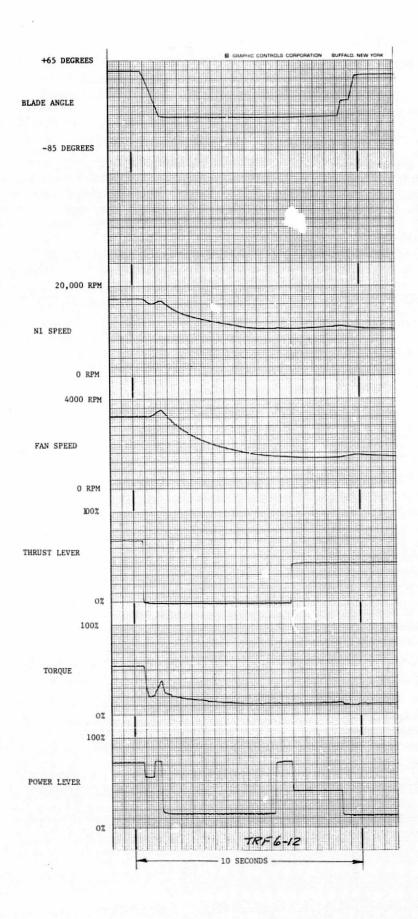


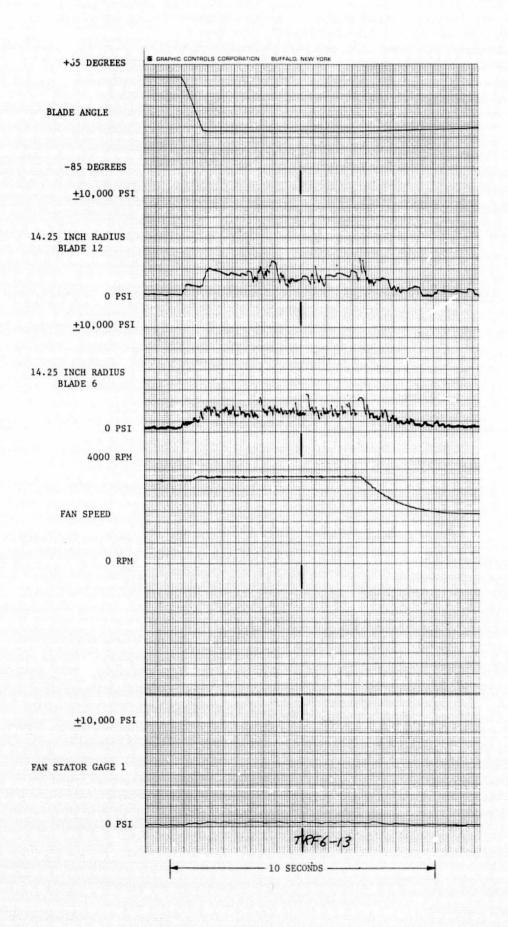


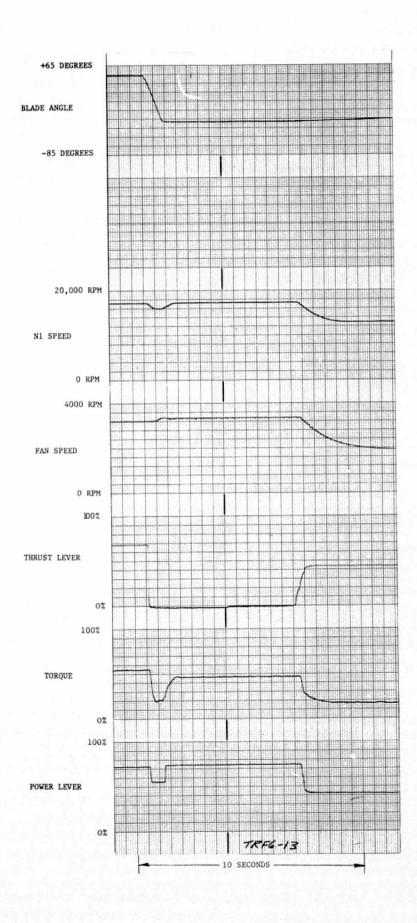


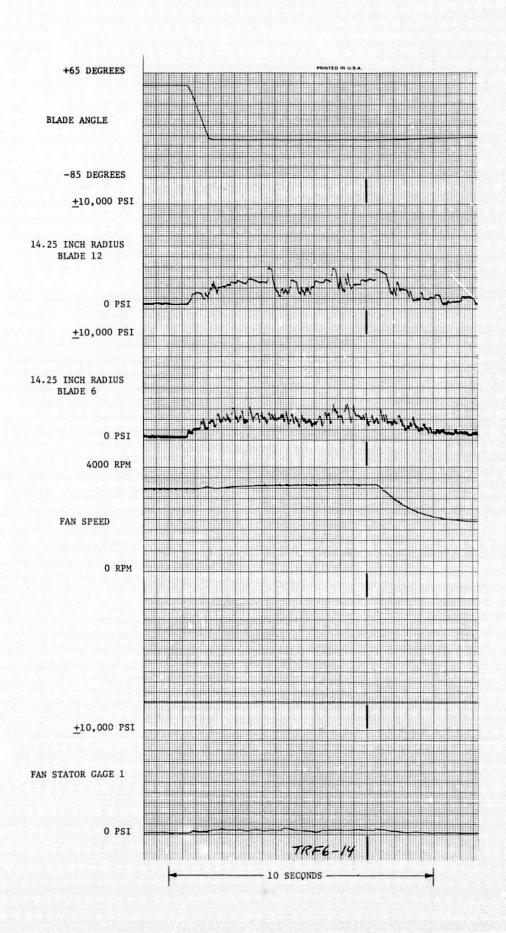


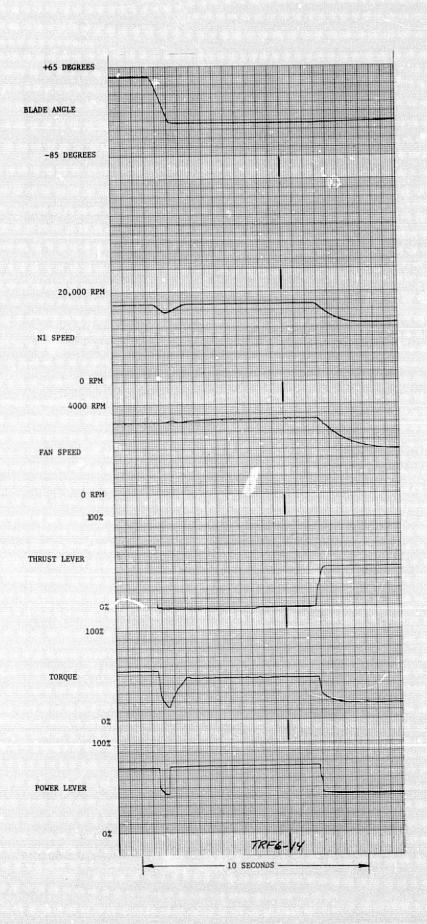


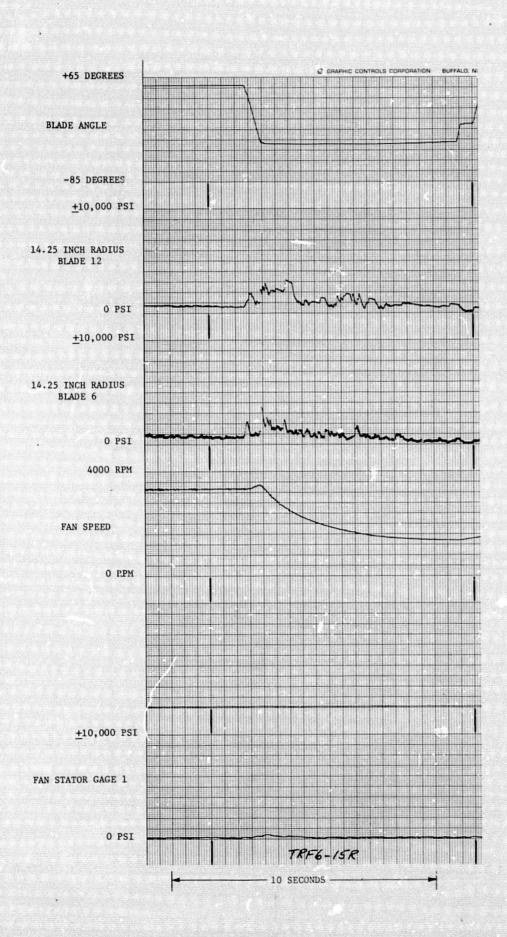


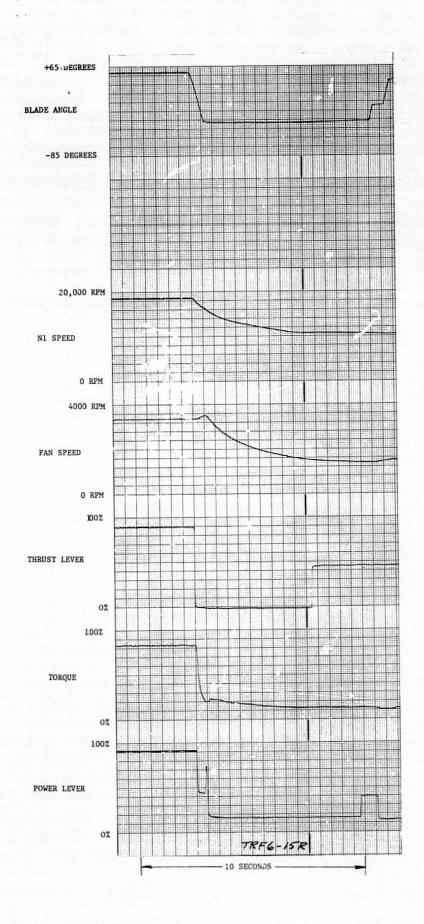


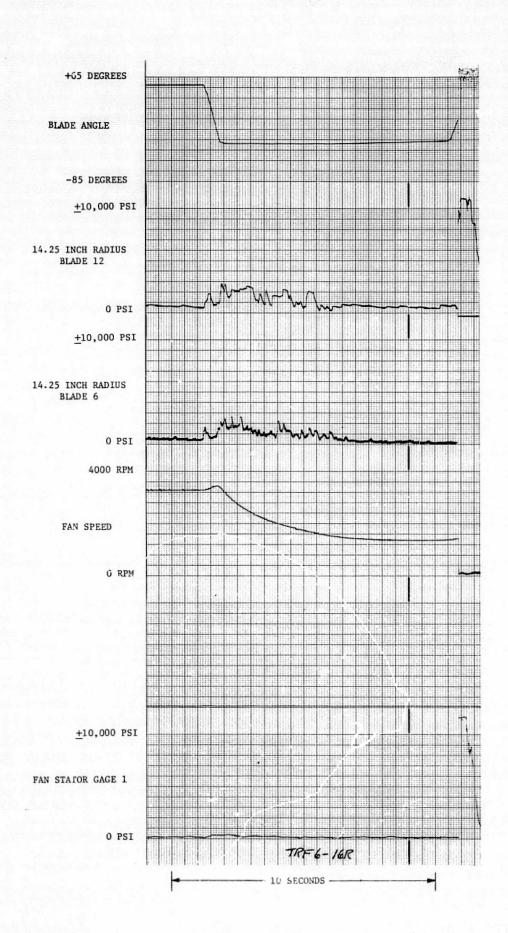


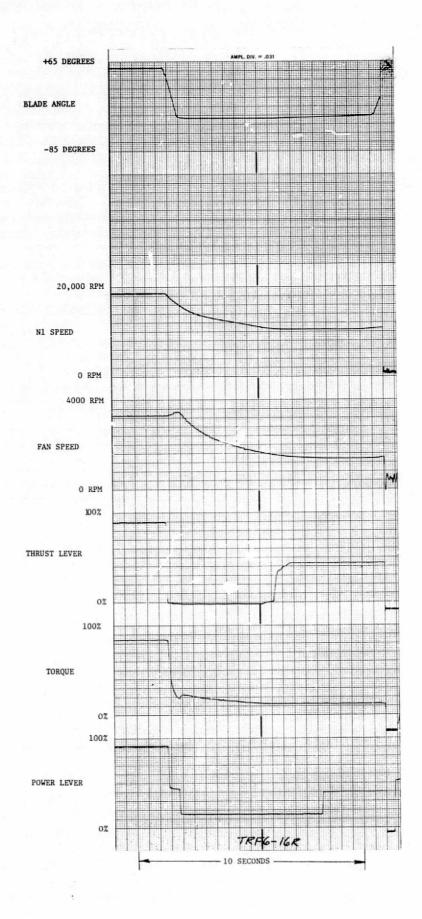


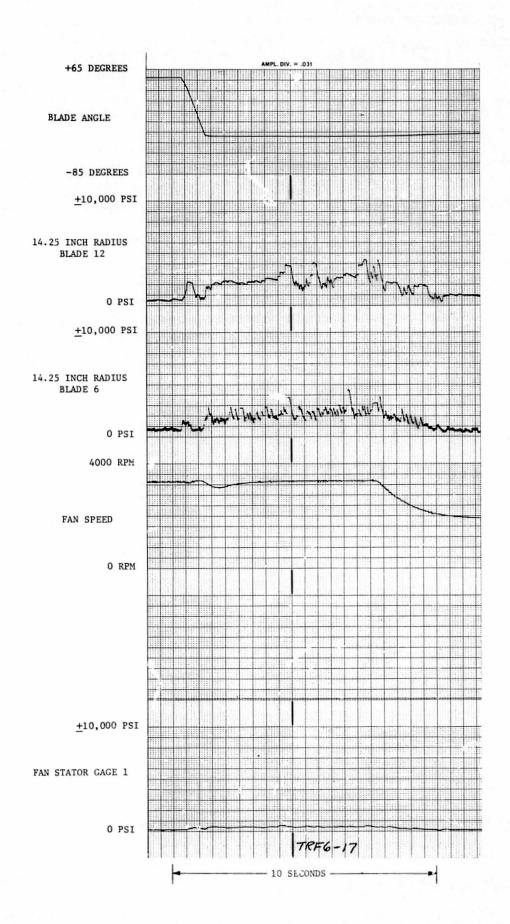


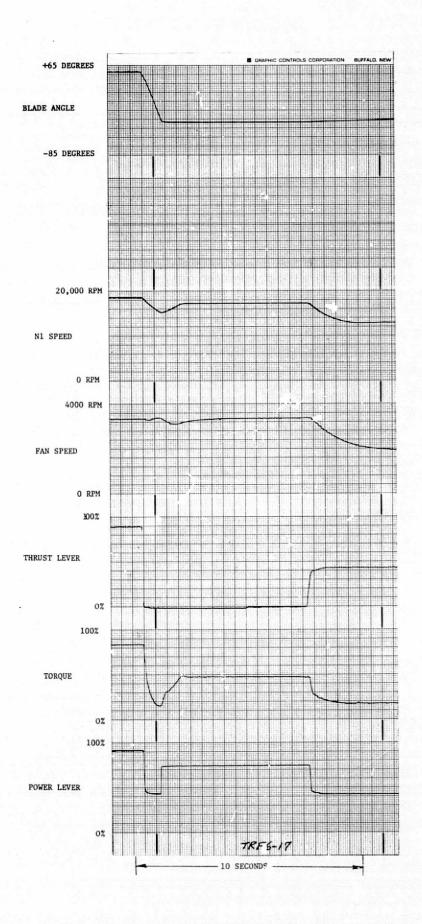


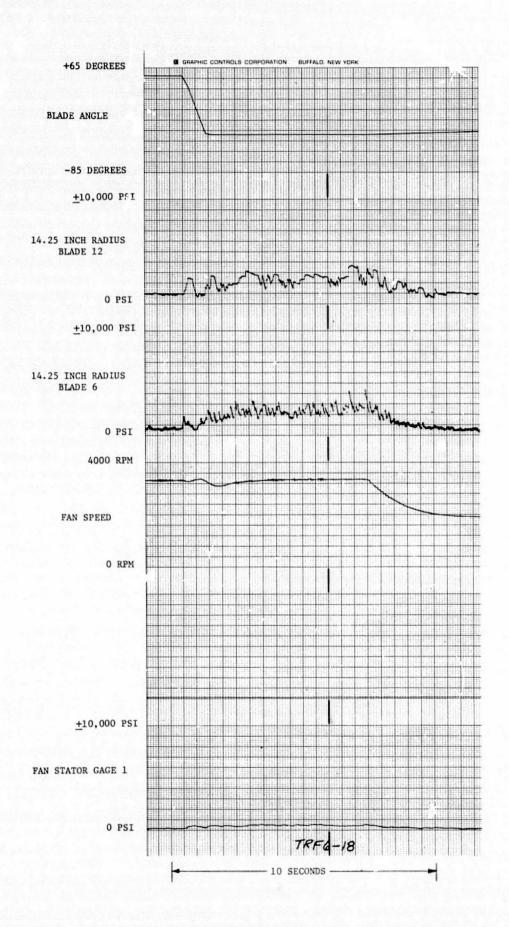


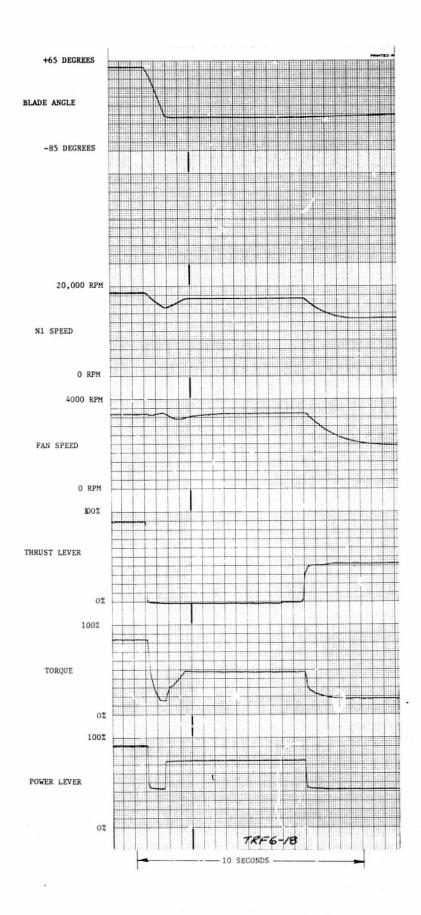


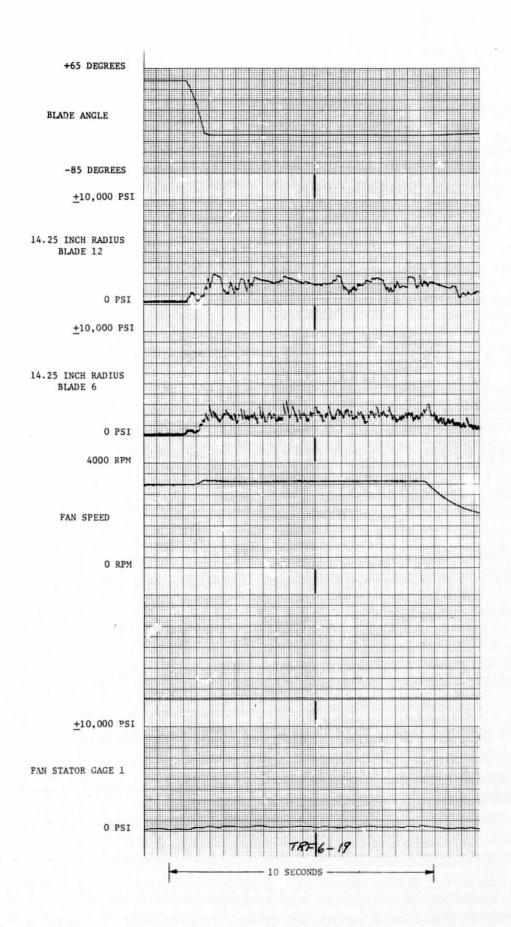


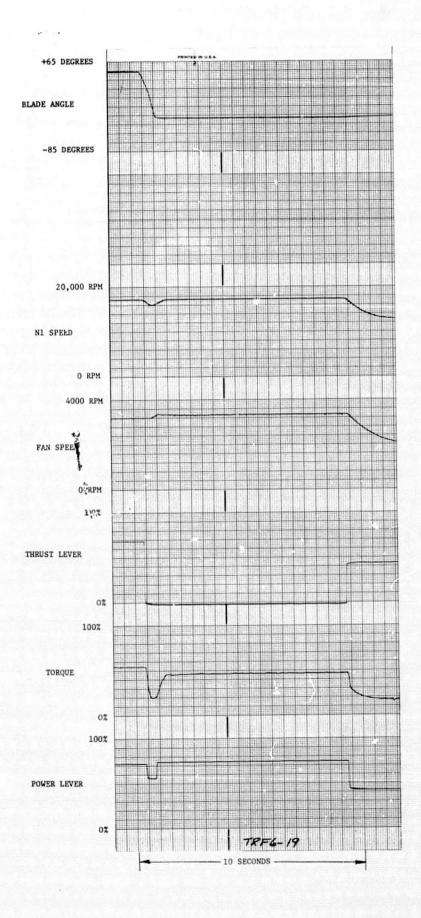


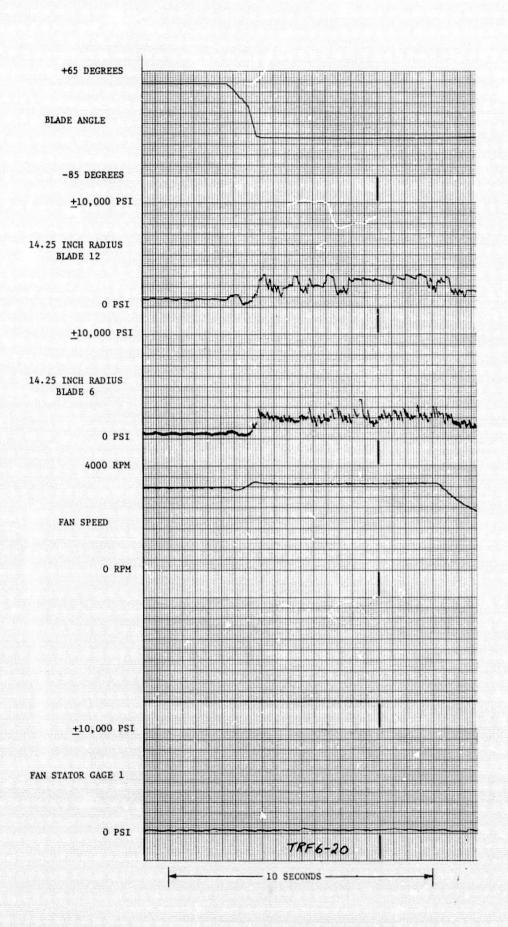


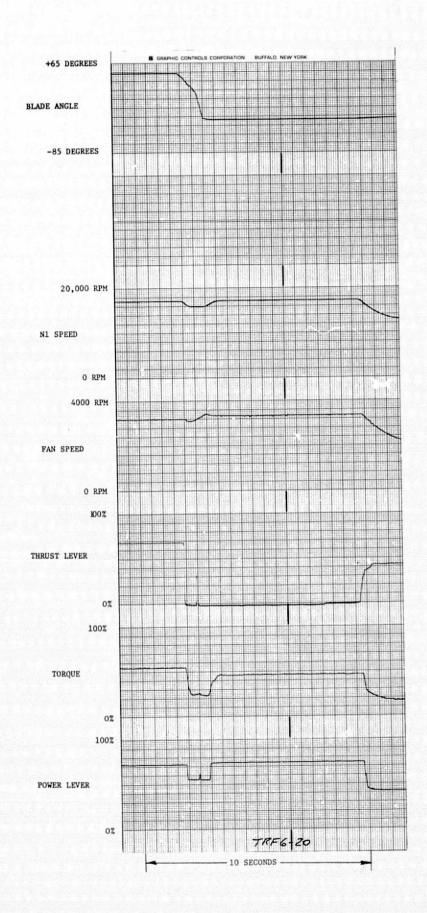






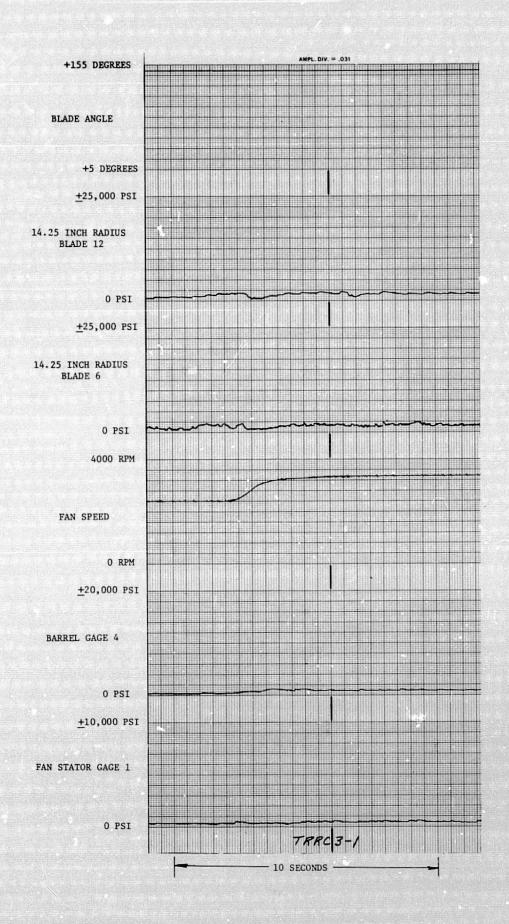


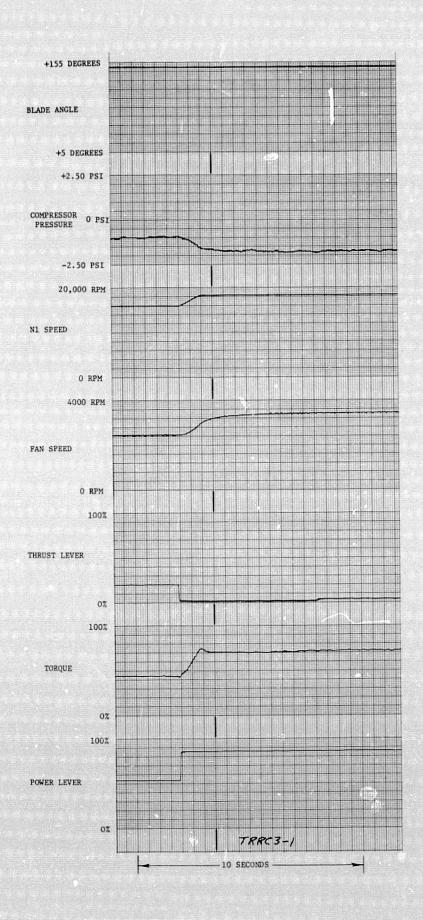


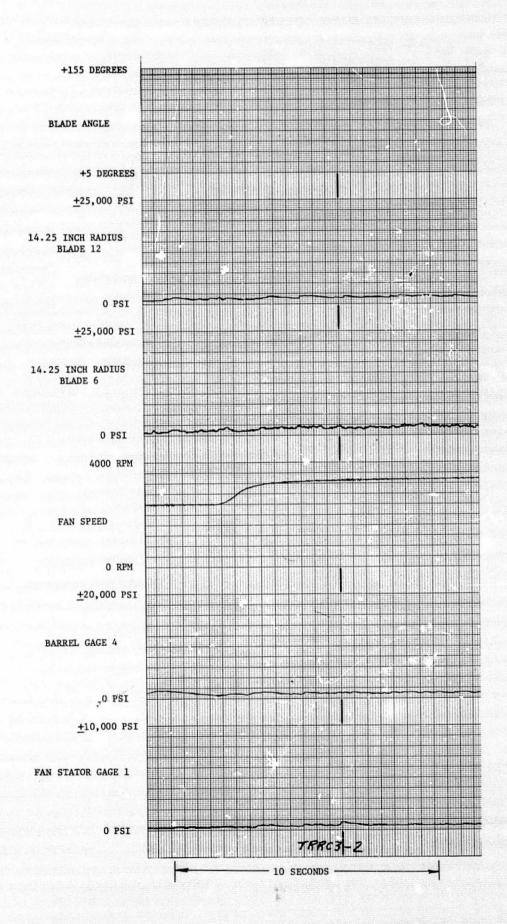


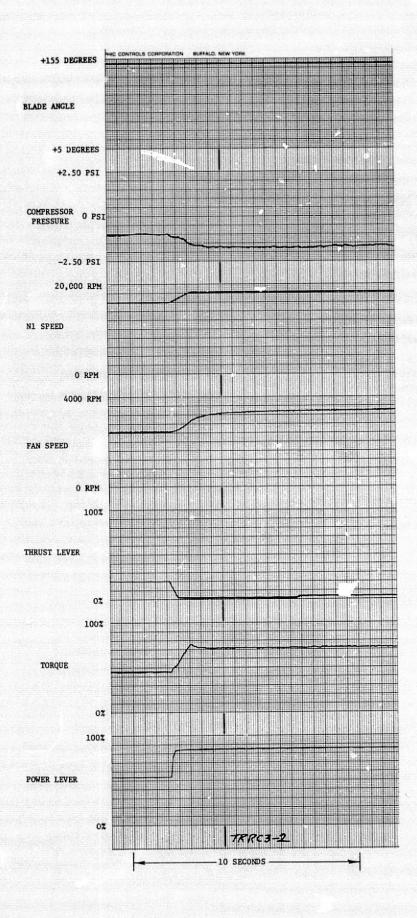
HSER 6700

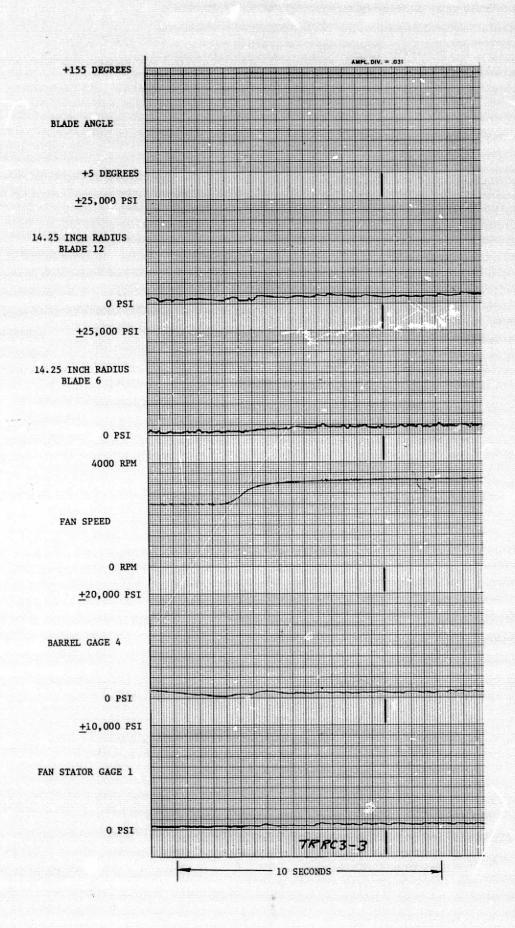
Reverse Thrust Transients - The following are Sanborn recordings of various parameters taped during the performance of the reverse thrust transients (TRRC) at the Hilltop facility at Hamilton Standard.



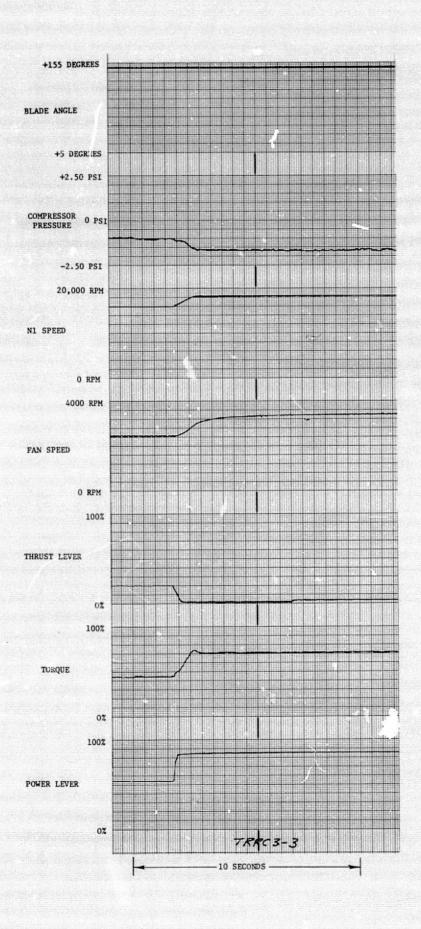


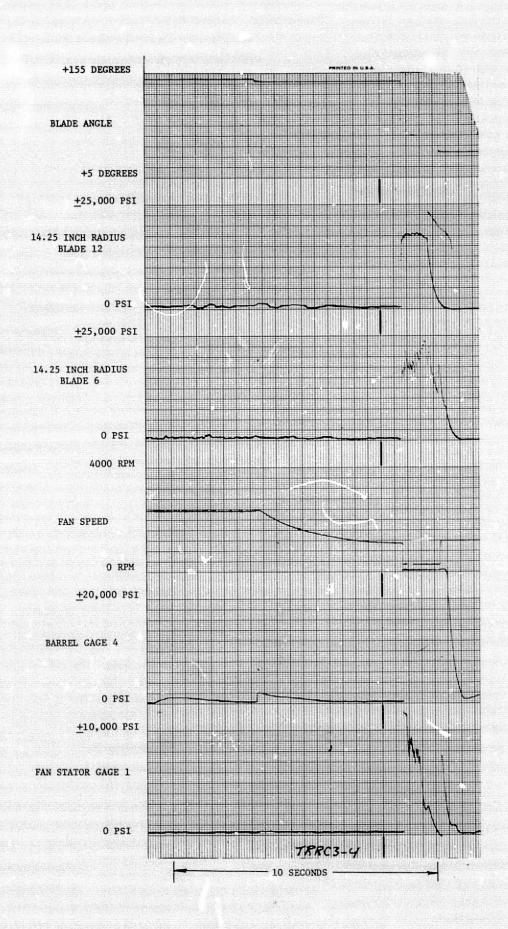


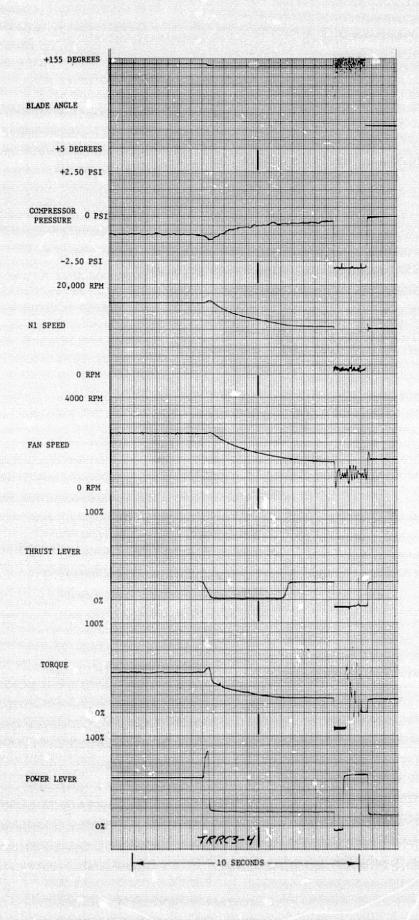




HSER 6700







ENGINE LOG

This section of Appendix F includes the engine test log sheets for this test program.. The information includes:

Start and Stop Times Test Time Total Time N₁ Speed N₂ Speed Gearbox Oil Flow Percent Torque T_{T7} Engine Oil Temperature Gearbox Oil Pressure Fuel Pressure Engine Oil Pressure Gearbox Bearing Temperature Gearbox Oil In and Out Temperatures Engine Skin Temperatures (6) Compressor Inlet Temperature Cowling Area Temperatures (2) Ambient Temperature Fan Blade Angle Power Lever Angle Thrust Setting Lever Angle Duct, Fan Gearbox, and Engine Vibrations (8) Actuator Increase and Decrease Pitch Pressures Actuator Supply Pressure PLA System Supply Pressure Barometric Pressure Test Point Number

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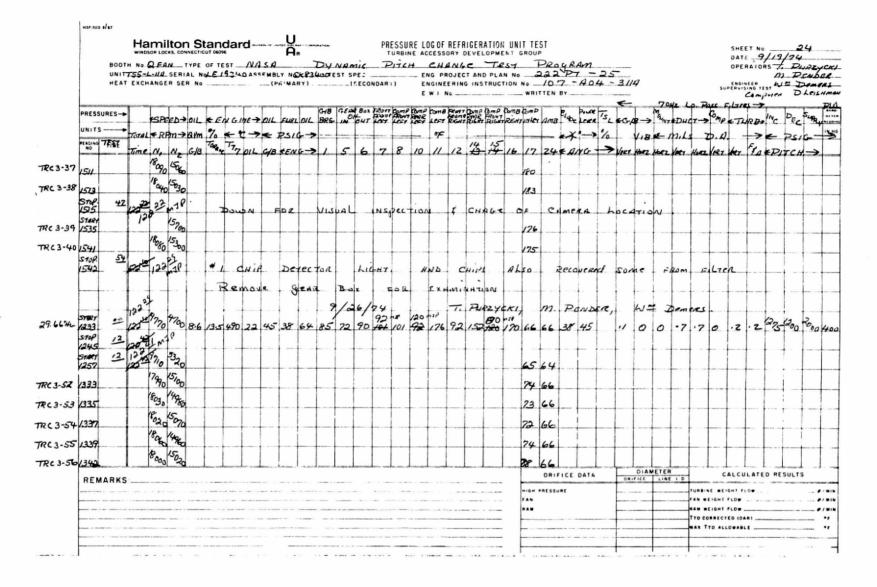
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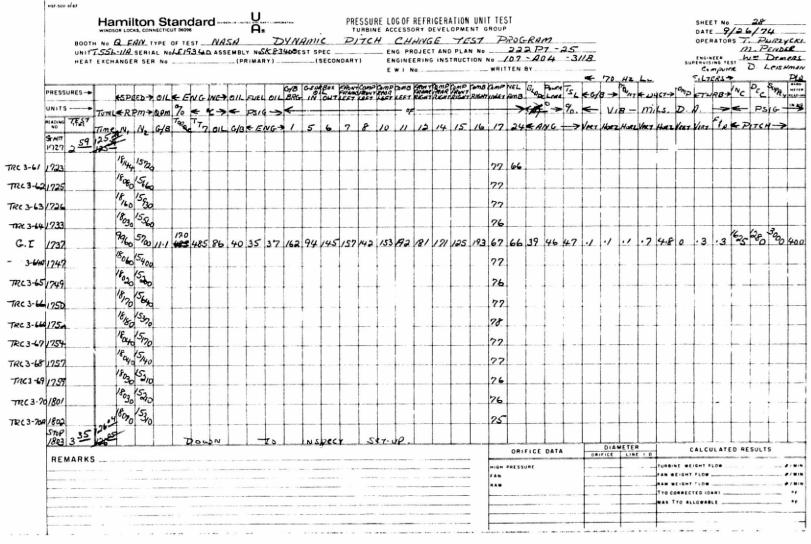


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PRESSURE LOG OF REFRIGERATION UNIT TEST

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HEAT EXCHANGER SER NO (PRIMARY) (SECONDARY) ENGINEERING INSTRUCTION NO 107-804-313A

and the many of the second section is

HSER 6700

DATE 12-5-74 OPERATORS F. GRECHIN

M. PENDER

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HSF-500 8/67

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